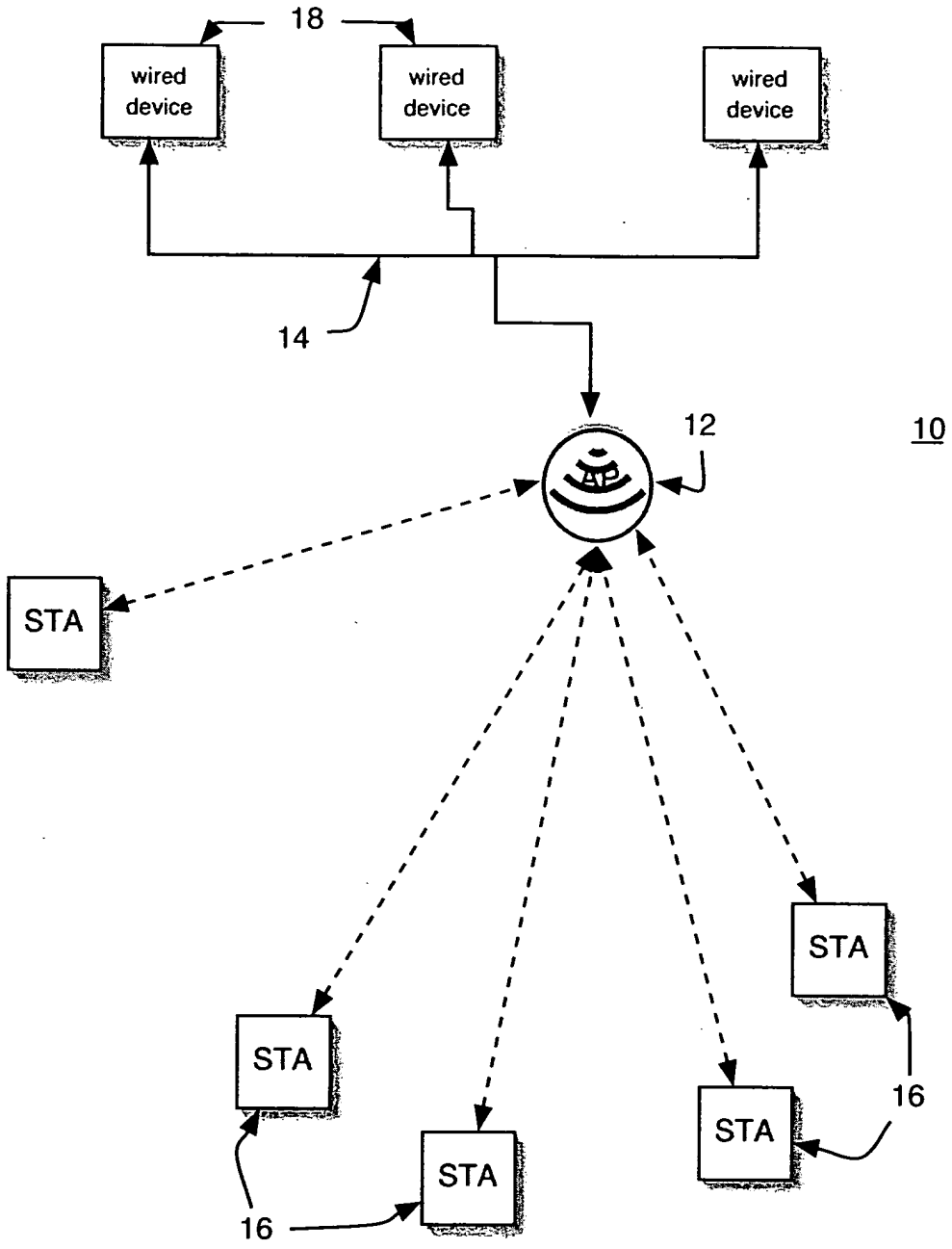

18
wired device
wired device
wired device
14
12
10
AP
STA
STA
STA
STA
STA
16
16

Fig. 1

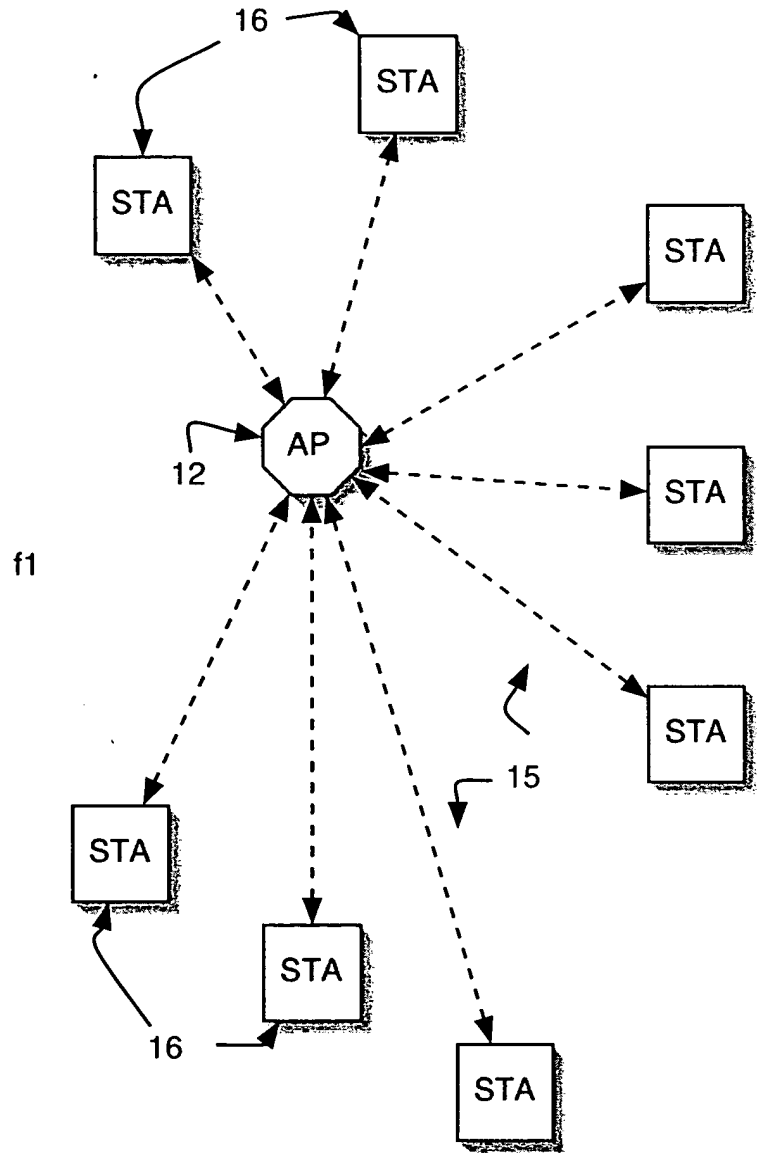


Fig. 2

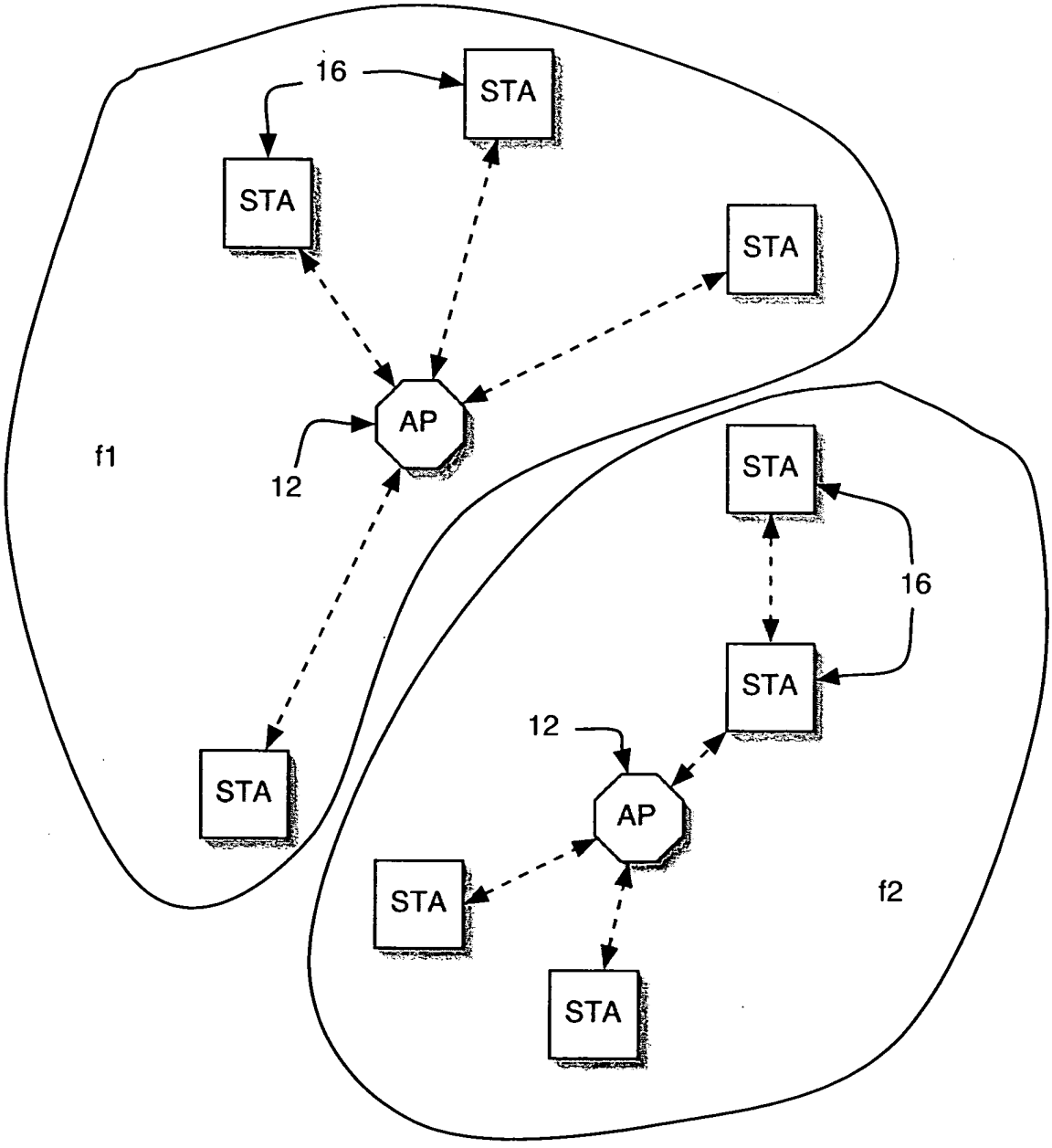


Fig. 3

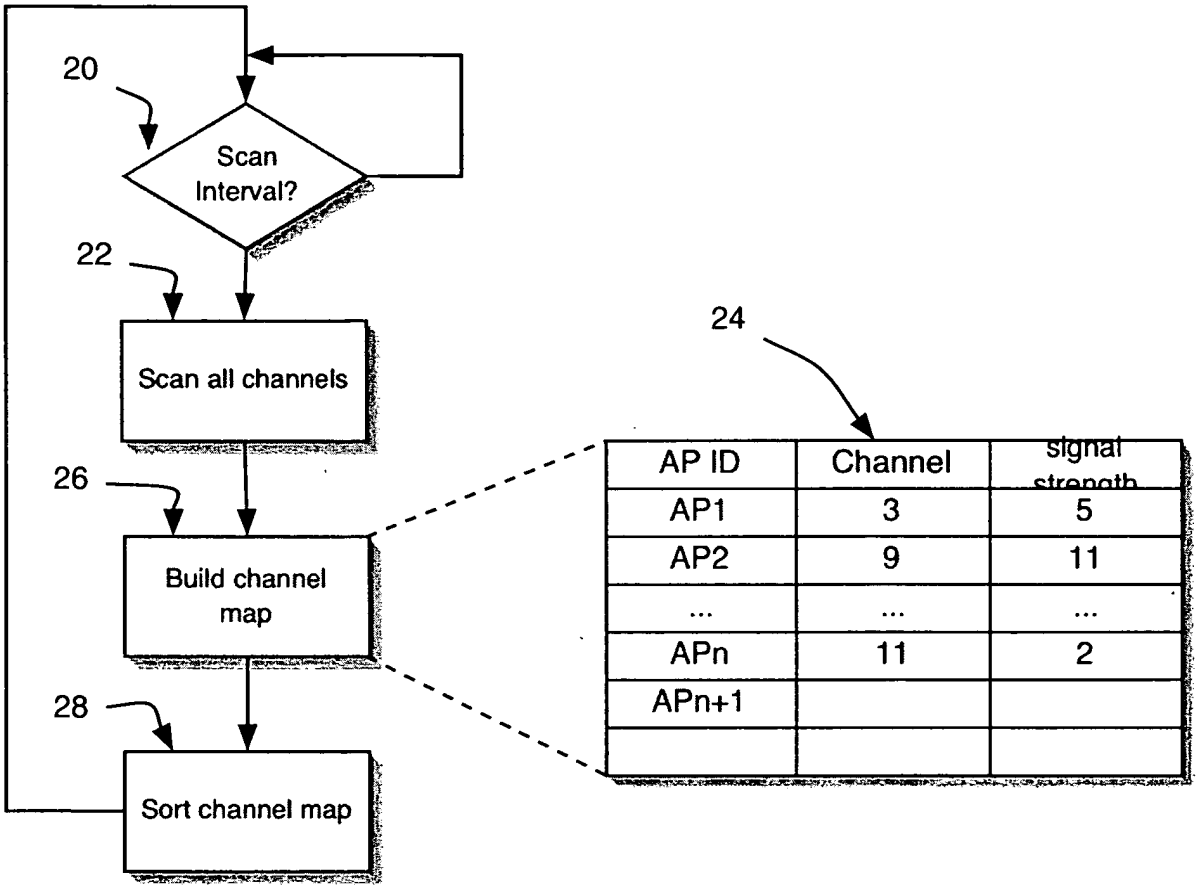

20
Scan Interval?
22
Scan all channels
24
26
Build channel map
28
Sort channel map
AP ID
Channel
signal strength
AP1
3
5
AP2
9
11
...
...
...
APn
11
2
APn+1

Fig. 4

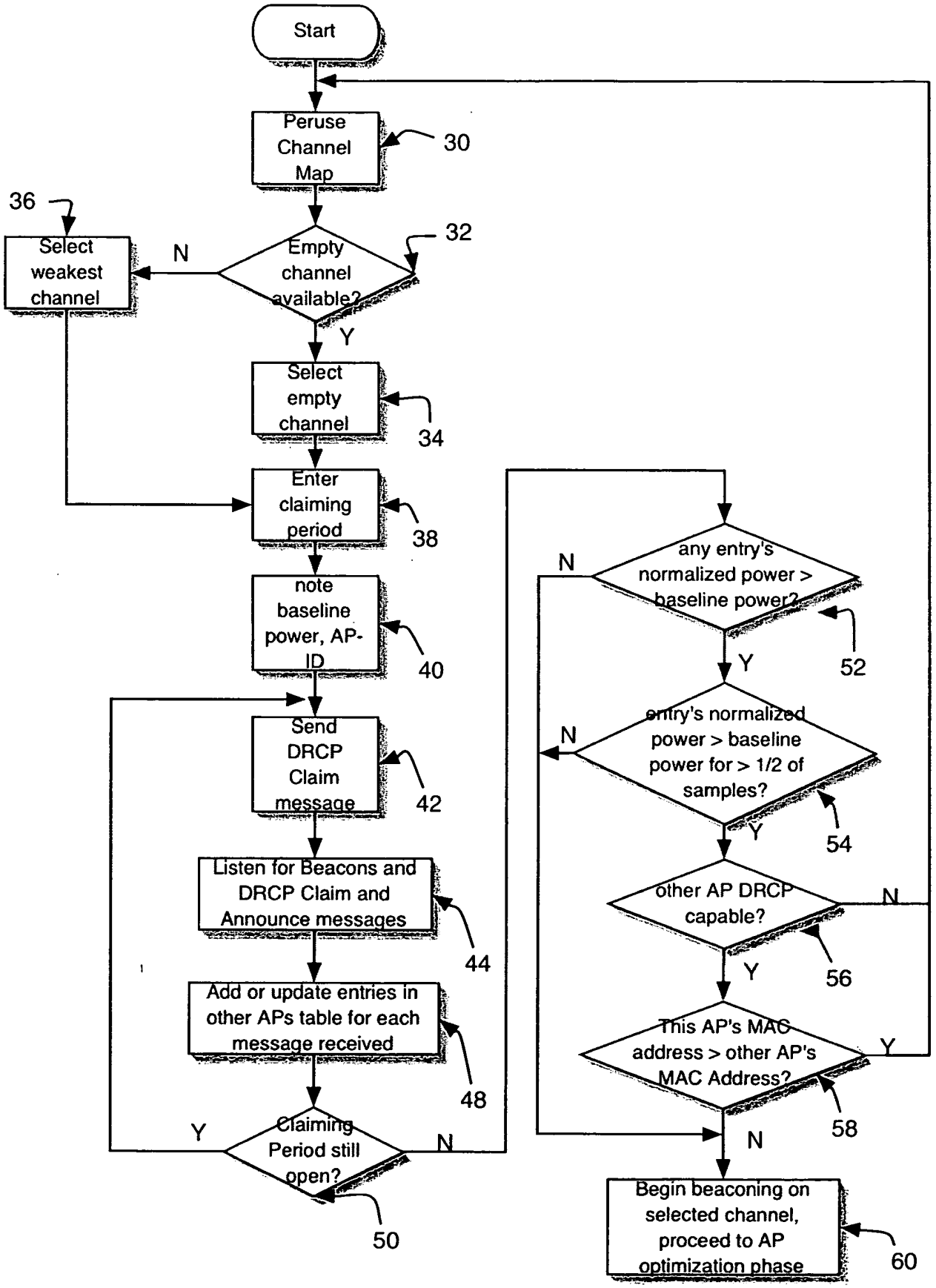

Start
Peruse Channel Map
30
36
Select weakest channel
N
Empty channel available?
32
Y
Select empty channel
34
Enter claiming period
38
note baseline power, AP-ID
40
Send DRCP Claim message
42
Listen for Beacons and DRCP Claim and Announce messages
44
Add or update entries in other APs table for each message received
48
Y
Claiming Period still open?
N
50
any entry's normalized power > baseline power?
N
52
Y
entry's normalized power > baseline power for > 1/2 of samples?
N
54
Y
other AP DRCP capable?
N
56
Y
This AP's MAC address > other AP's MAC Address?
Y
58
N
Begin beaconing on selected channel, proceed to AP optimization phase
60

Fig. 5

46

AP_ID	received power	TP Backoff	DRCP	Normalized received power
AP[1]	<list>	<list>	1	
AP[2]	0	?	0	
...	...	...	...	...
AP[n]	<list>	<list>	1	

Other APs Table

Fig. 6

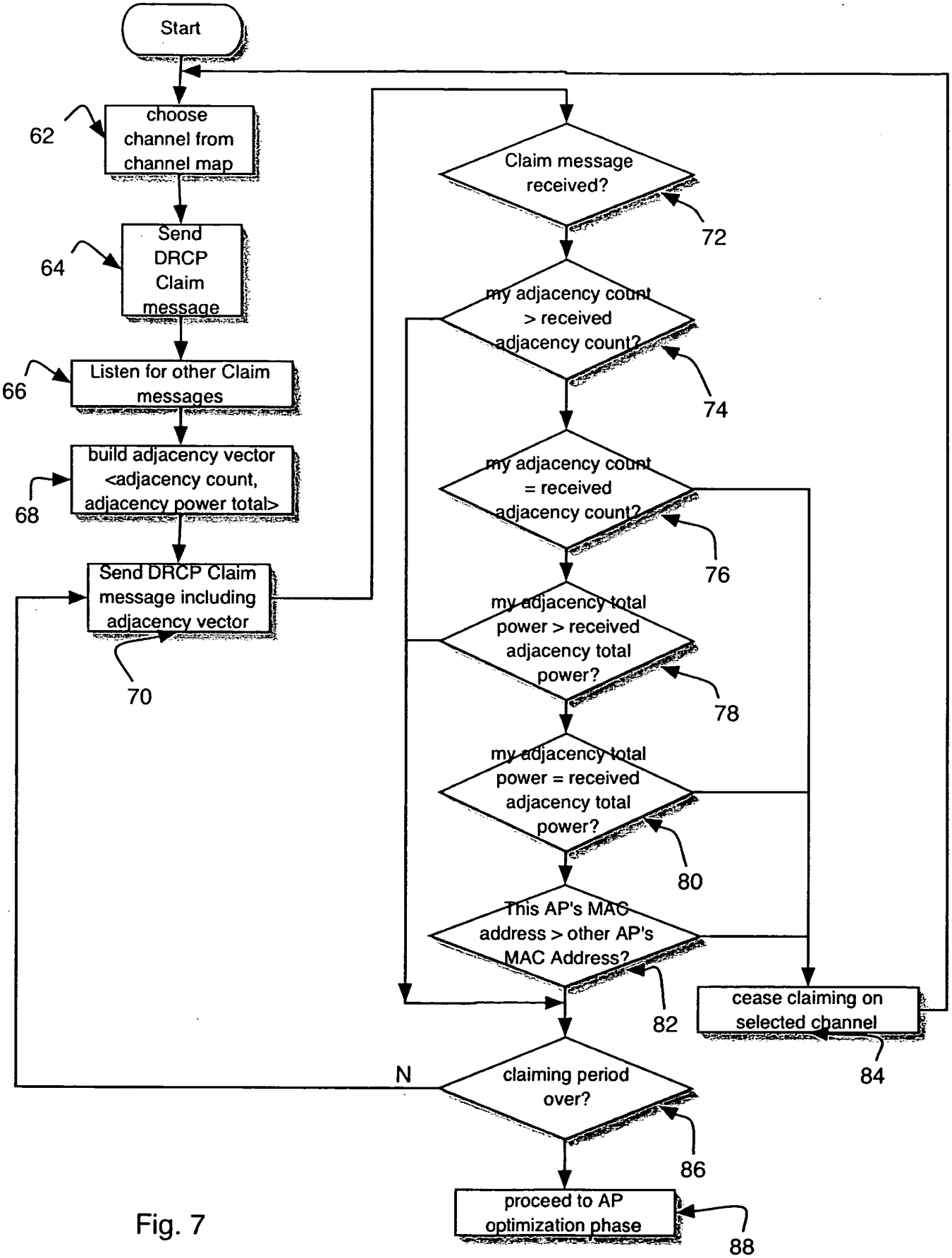

Start
choose channel from channel map
62
Send DRCP Claim message
64
Listen for other Claim messages
66
build adjacency vector <adjacency count, adjacency power total>
68
Send DRCP Claim message including adjacency vector
70
Claim message received?
72
my adjacency count > received adjacency count?
74
my adjacency count = received adjacency count?
76
my adjacency total power > received adjacency total power?
78
my adjacency total power = received adjacency total power?
80
This AP's MAC address > other AP's MAC Address?
82
cease claiming on selected channel
84
N
claiming period over?
86
proceed to AP optimization phase
88

Fig. 7

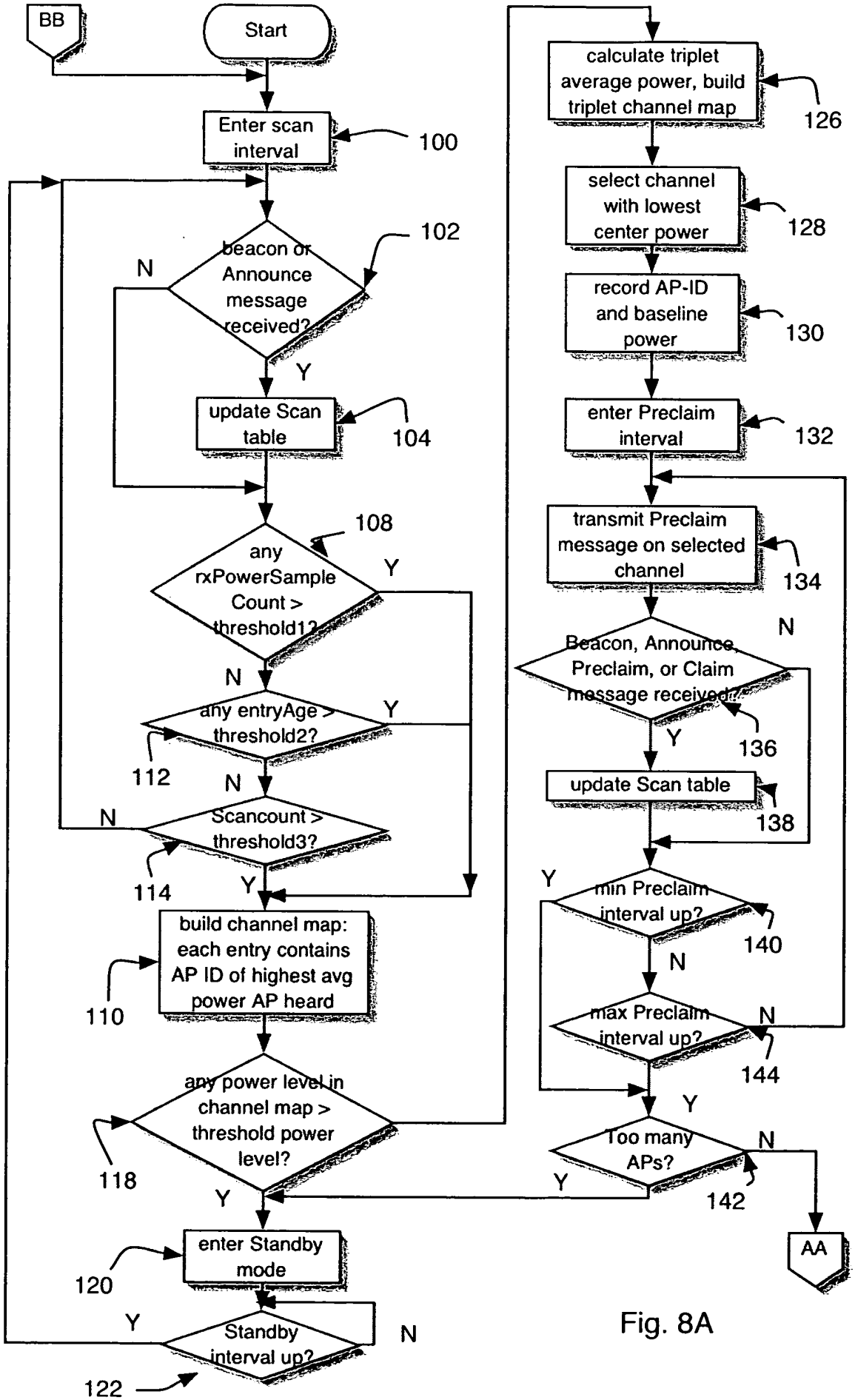

BB
Start
Enter scan interval
100
beacon or Announce message received?
102
N
Y
update Scan table
104
any rxPowerSample Count > threshold1?
108
Y
N
any entryAge > threshold2?
Y
112
N
Scancount > threshold3?
N
114
Y
build channel map: each entry contains AP ID of highest avg power AP heard
110
any power level in channel map > threshold power level?
118
Y
enter Standby mode
120
Y
Standby interval up?
N
122
calculate triplet average power, build triplet channel map
126
select channel with lowest center power
128
record AP-ID and baseline power
130
enter Preclaim interval
132
transmit Preclaim message on selected channel
134
Beacon, Announce, Preclaim, or Claim message received?
N
Y
136
update Scan table
138
min Preclaim interval up?
Y
140
N
max Preclaim interval up?
N
144
Y
Too many APs?
N
Y
142
AA

Fig. 8A

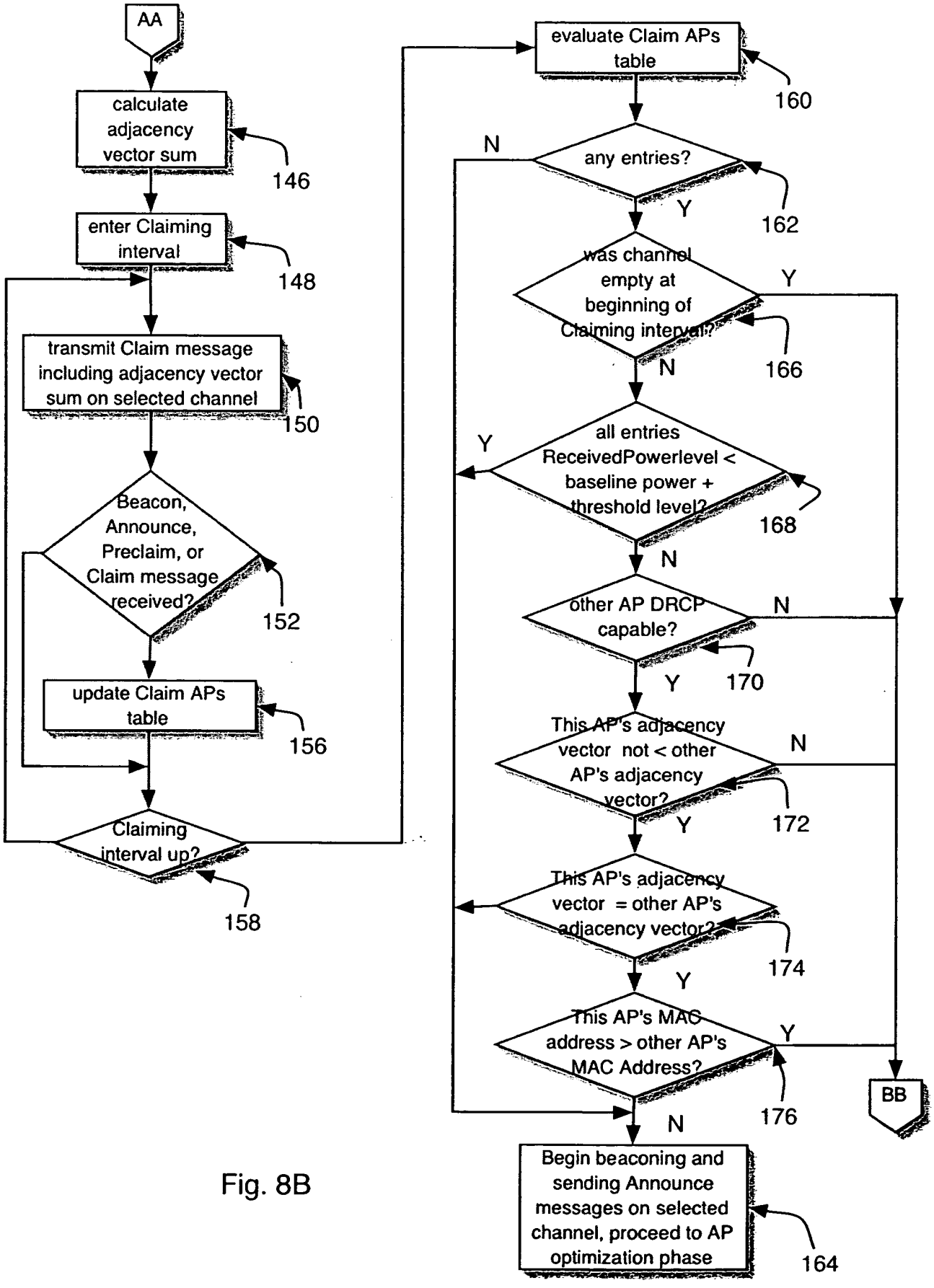

AA
calculate adjacency vector sum
146
enter Claiming interval
148
transmit Claim message including adjacency vector sum on selected channel
150
Beacon, Announce, Preclaim, or Claim message received?
152
update Claim APs table
156
Claiming interval up?
158
evaluate Claim APs table
160
any entries?
N
Y
162
was channel empty at beginning of Claiming interval?
Y
N
166
all entries ReceivedPowerlevel < baseline power + threshold level?
Y
168
N
other AP DRCP capable?
N
Y
170
This AP's adjacency vector not < other AP's adjacency vector?
N
Y
172
This AP's adjacency vector = other AP's adjacency vector?
174
Y
This AP's MAC address > other AP's MAC Address?
Y
176
N
BB
Begin beaconing and sending Announce messages on selected channel, proceed to AP optimization phase
164

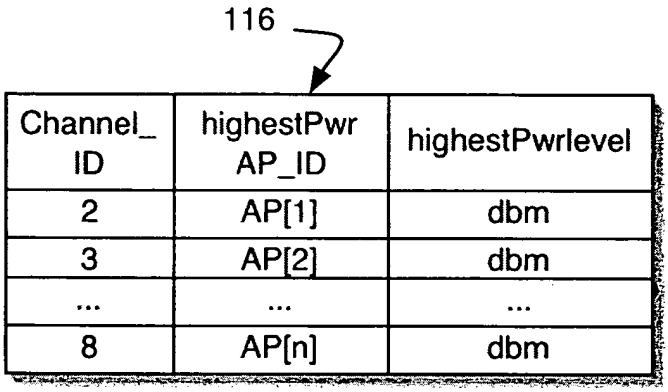
Fig. 8B

106

AP_ID	Channel_ ID	rxPowerRunning Total	rxPowerSample Count	rxPowerAvg	DRCP	Age
AP[1]	3	dbm	3	dbm	1	3
AP[2]	3	dbm	5	dbm	0	7
...	...	dbm	...	...	...	...
AP[n]	5	dbm	8	dbm	1	4

Scan Table

Fig. 9



Channel Map

Fig. 10

124

Channel	signal strength	Triplet avg	AP ID
2	5	5	3
3	2	5	11
4	8	5	2
1	3	6	8
2	9	6	6
3	6	6	1

Triplet channel map

Fig. 11

154

AP-ID	ReceivedPowerlevel	DRCP
2	<list>	5
3	<list>	7
4	<list>	3
7	<list>	6
9	<list>	9
11	<list>	12

Claim APs table

Fig. 12

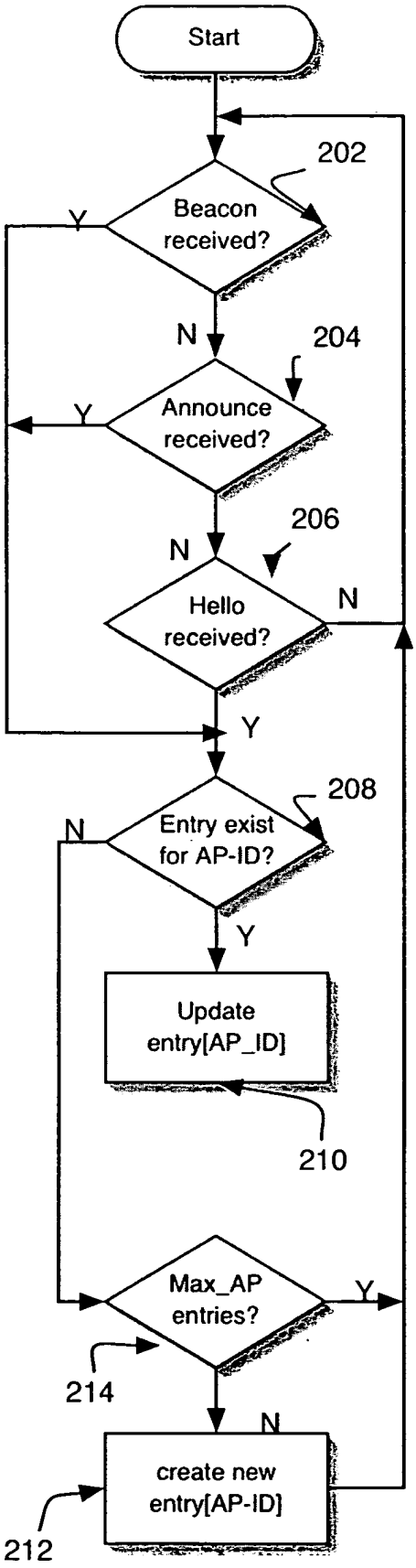
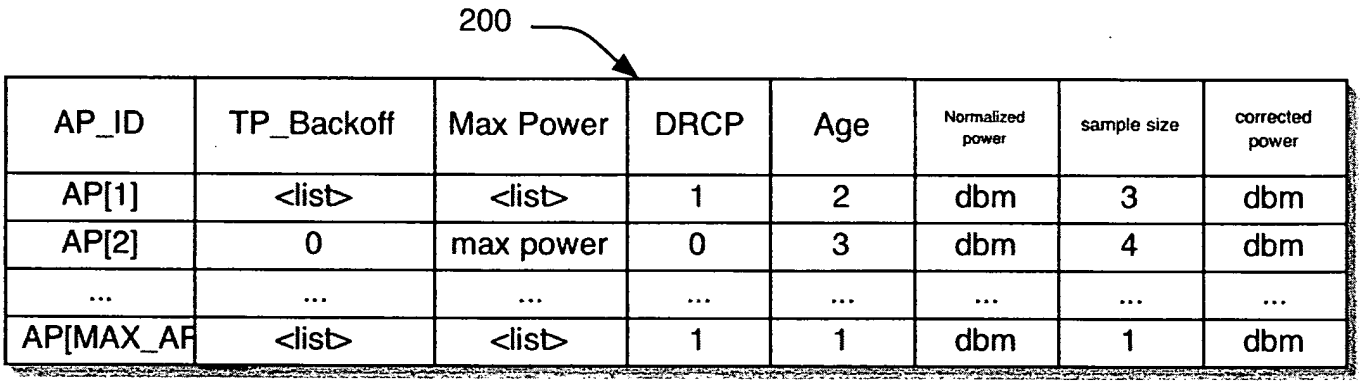

Start
202
Beacon received?
Y
N
204
Announce received?
Y
N
206
Hello received?
N
Y
208
Entry exist for AP-ID?
N
Y
Update entry[AP_ID]
210
Max_AP entries?
Y
214
N
create new entry[AP-ID]
212

Fig. 13



AP_ID	TP_Backoff	Max Power	DRCP	Age	Normalized power	sample size	corrected power
AP[1]	<list>	<list>	1	2	dbm	3	dbm
AP[2]	0	max power	0	3	dbm	4	dbm
...	...	...	...	...	...	...	...
AP[MAX_AP	<list>	<list>	1	1	dbm	1	dbm

AP Known APs Table

Fig. 14

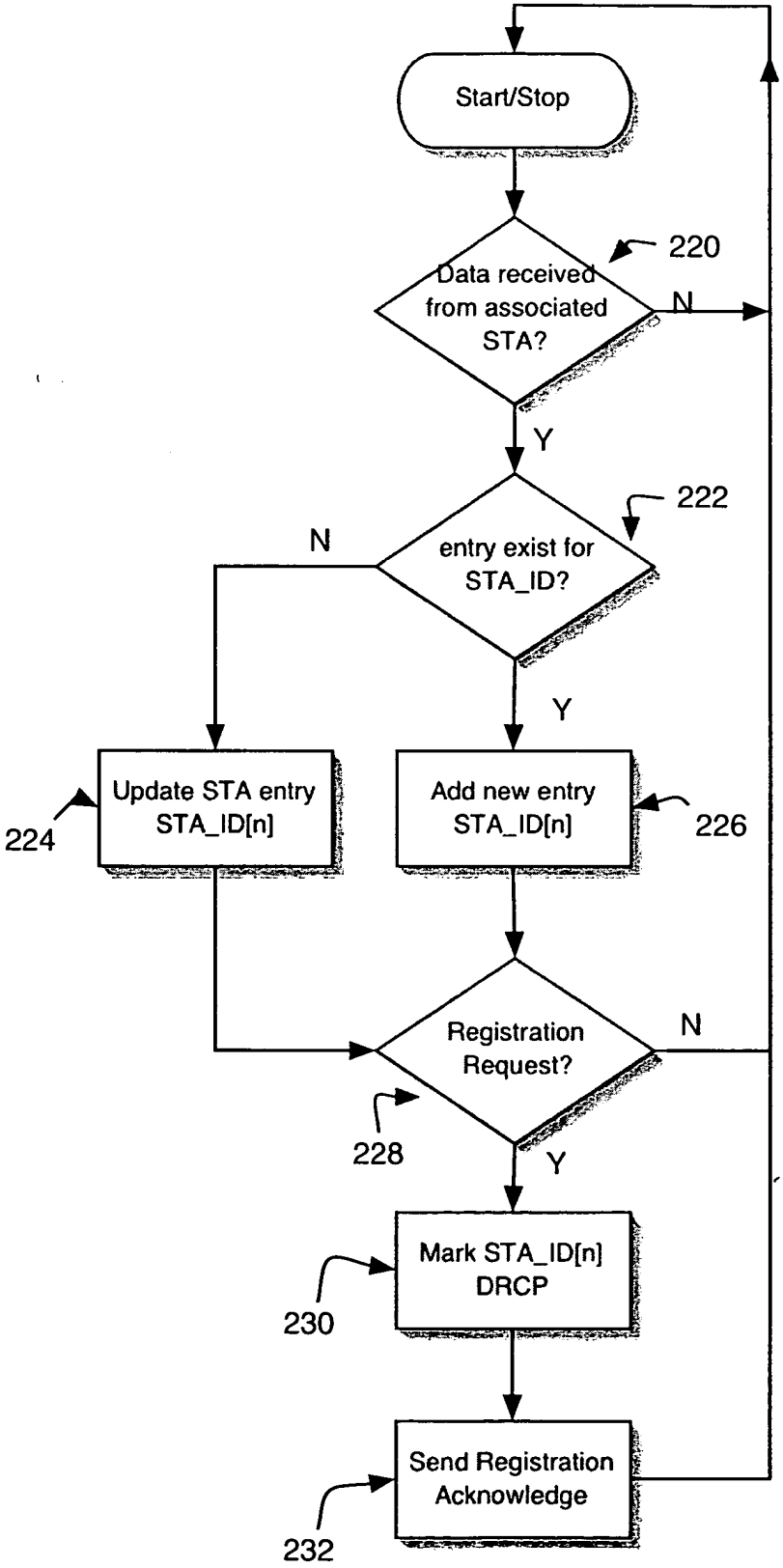

Start/Stop
Data received from associated STA?
220
N
Y
entry exist for STA_ID?
222
N
Y
Update STA entry STA_ID[n]
224
Add new entry STA_ID[n]
226
Registration Request?
228
N
Y
Mark STA_ID[n] DRCP
230
Send Registration Acknowledge
232

Fig. 15

240

STA_ID	Quiet-time	DRCP-Active	Distance	max power	sta_load_factor	power samples	normalized_power	corrected_power
STA[1]	4	1	1	1	2	1	1	1
STA[2]	0	0	0	0	3	0	0	0
...	...	...	...	...	...	...	...	...
STA[n]	6	1	3	1	1	1	1	1

AP AssociatedSTA Table

Fig. 16

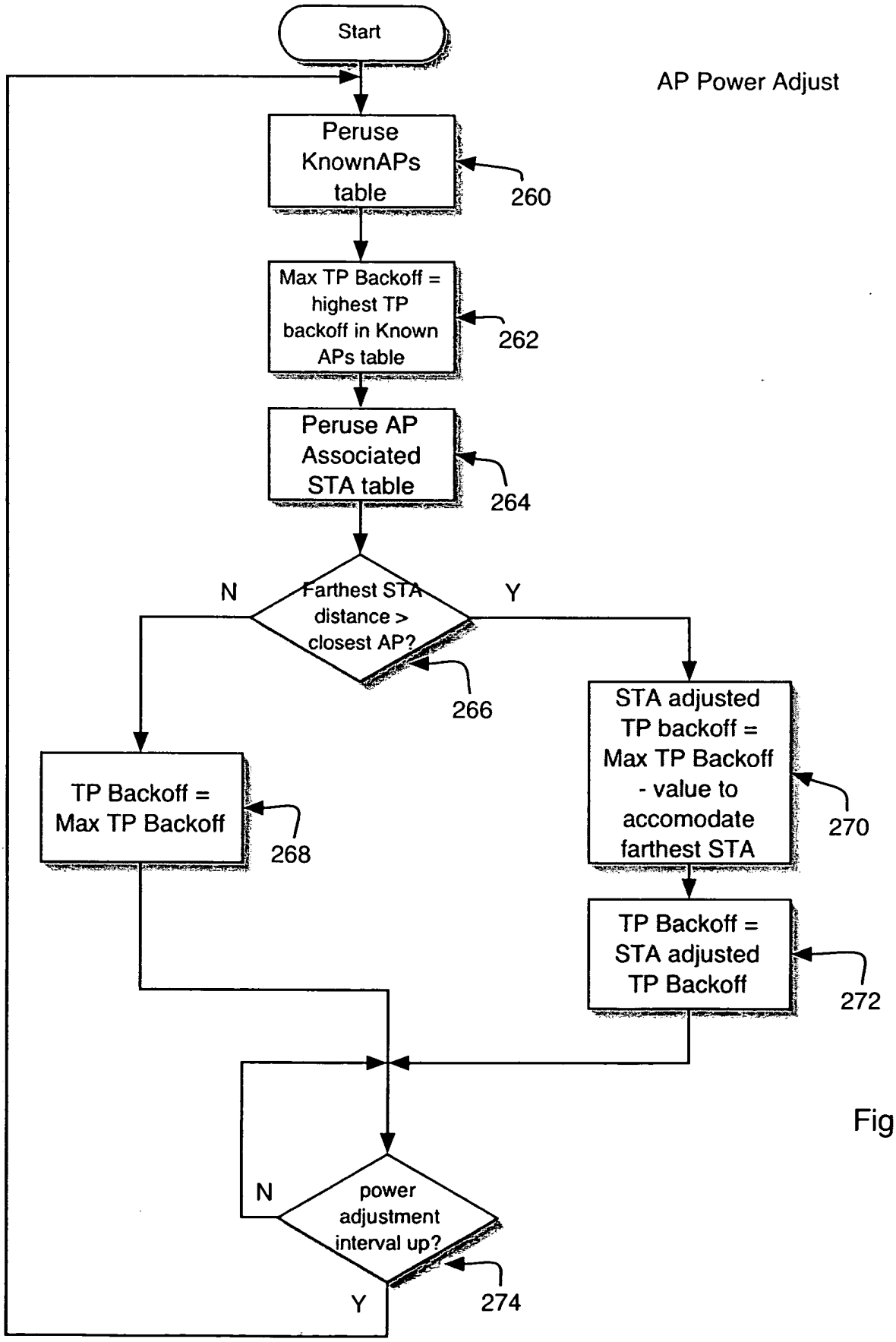

AP Power Adjust
Start
Peruse KnownAPs table
260
Max TP Backoff = highest TP backoff in Known APs table
262
Peruse AP Associated STA table
264
Farthest STA distance > closest AP?
N
Y
266
TP Backoff = Max TP Backoff
268
STA adjusted TP backoff = Max TP Backoff - value to accomodate farthest STA
270
TP Backoff = STA adjusted TP Backoff
272
power adjustment interval up?
N
Y
274

Fig. 17

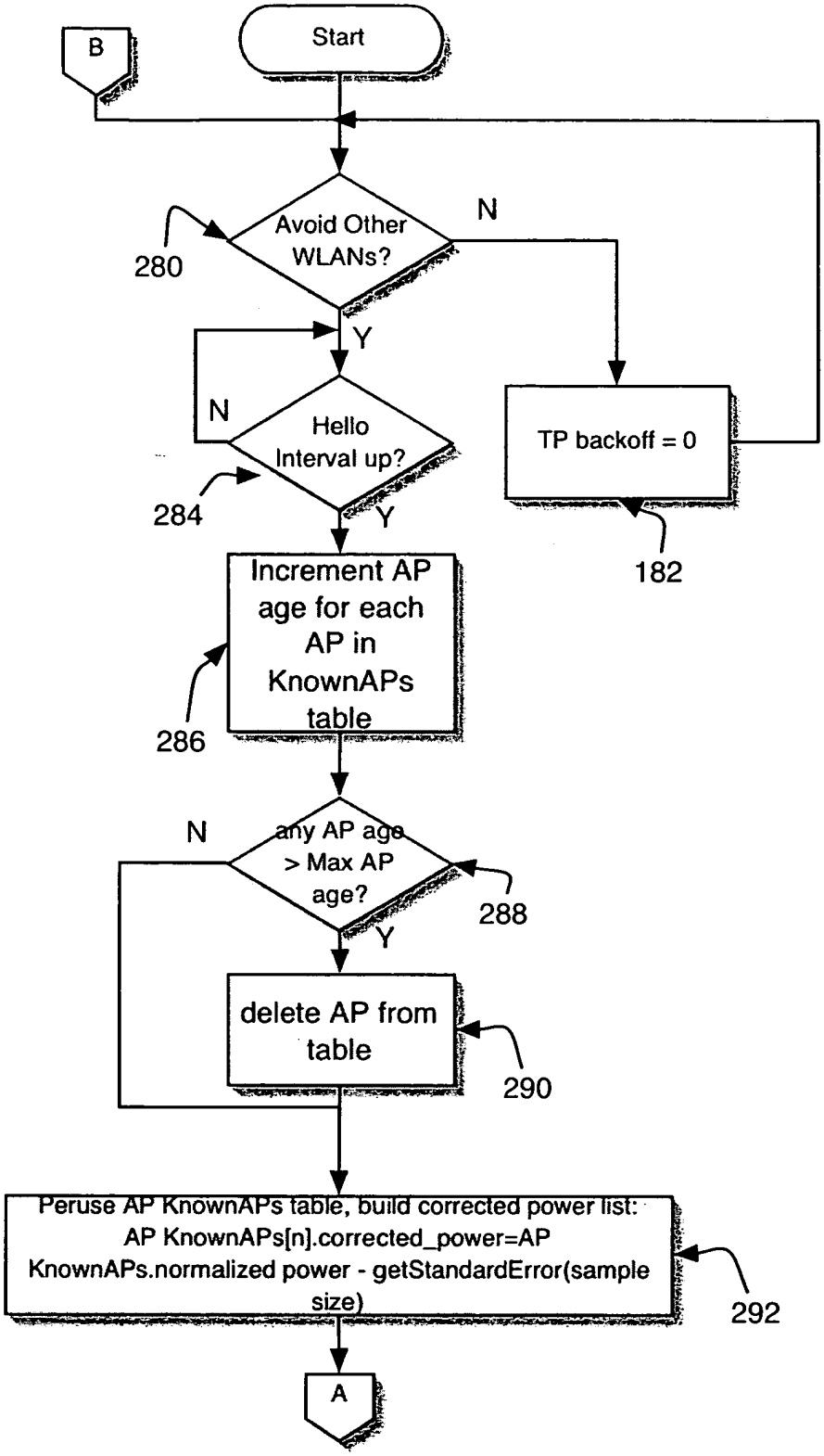

B
Start
Avoid Other WLANs?
280
N
Y
Hello Interval up?
N
284
Y
TP backoff = 0
182
Increment AP age for each AP in KnownAPs table
286
any AP age > Max AP age?
N
288
Y
delete AP from table
290
Peruse AP KnownAPs table, build corrected power list: AP KnownAPs[n].corrected_power=AP KnownAPs.normalized power - getStandardError(sample size)
292
A

Fig. 18A

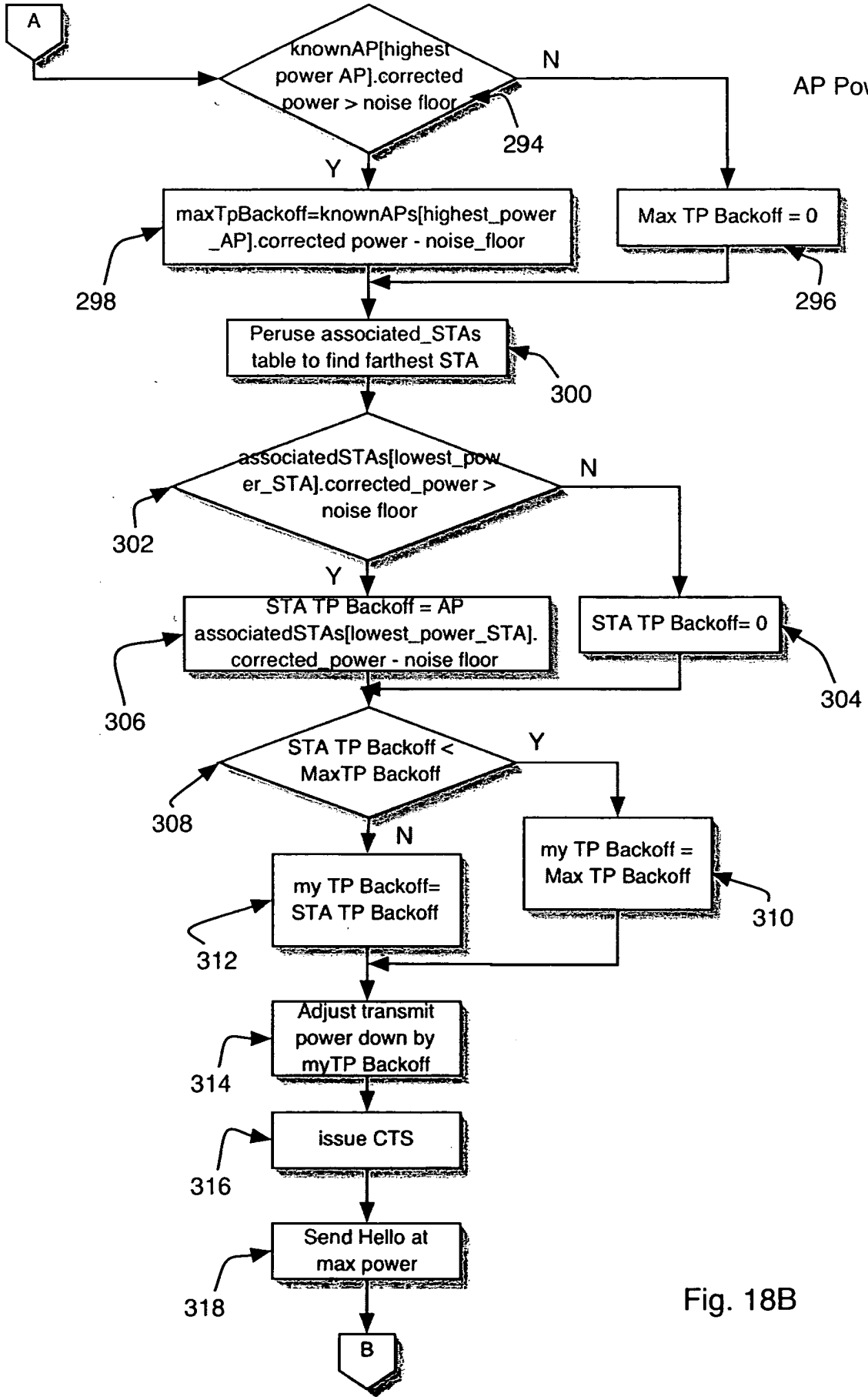

A
knownAP[highest power AP].corrected power > noise floor
N
Y
294
AP Power adjust
maxTpBackoff=knownAPs[highest_power_AP].corrected power - noise_floor
Max TP Backoff = 0
298
296
Peruse associated_STAs table to find farthest STA
300
associatedSTAs[lowest_power_STA].corrected_power > noise floor
N
302
Y
STA TP Backoff = AP associatedSTAs[lowest_power_STA].corrected_power - noise floor
STA TP Backoff= 0
304
306
STA TP Backoff < MaxTP Backoff
Y
308
N
my TP Backoff = Max TP Backoff
310
my TP Backoff= STA TP Backoff
312
Adjust transmit power down by myTP Backoff
314
issue CTS
316
Send Hello at max power
318
B

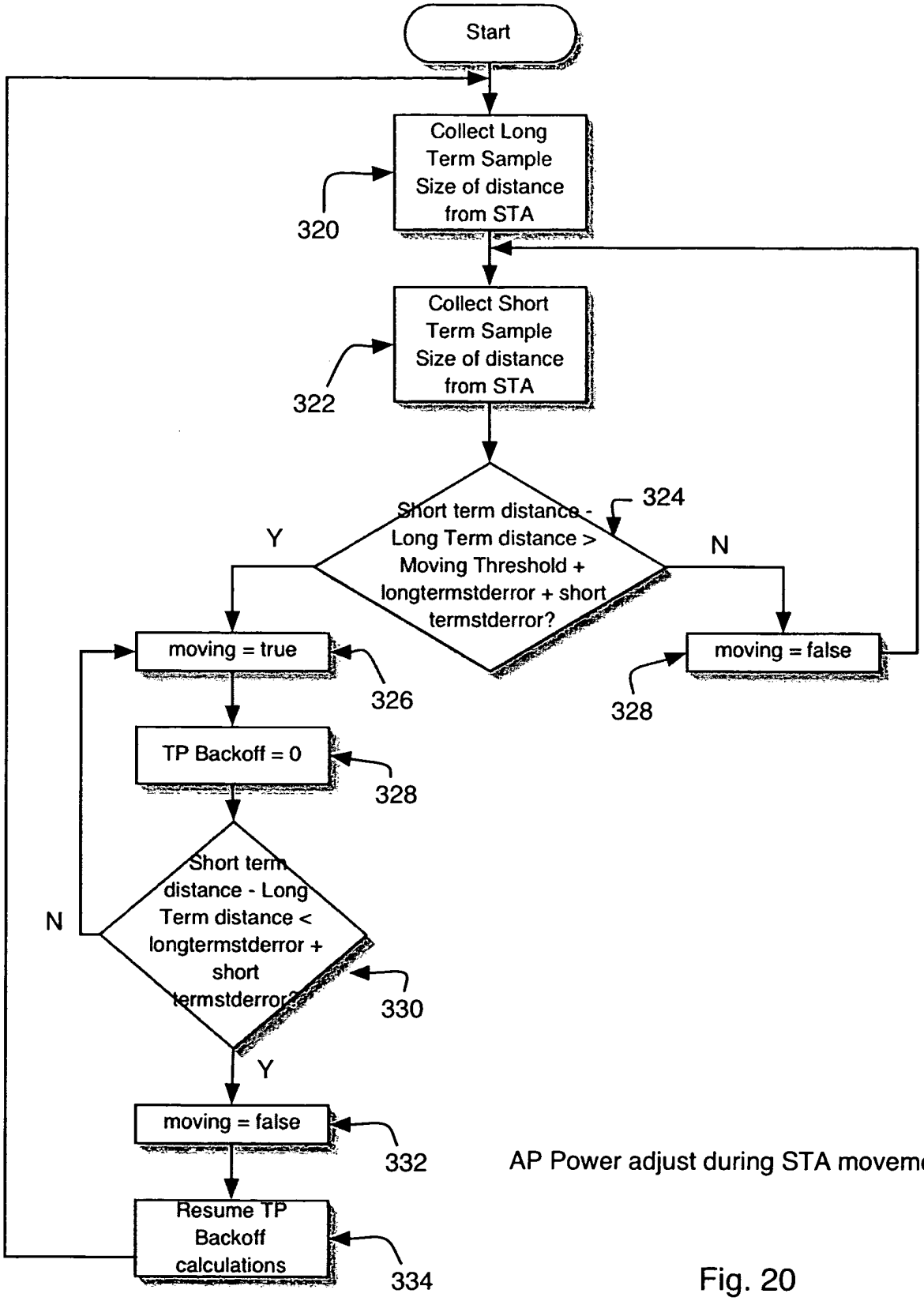
Fig. 18B

Number of Samples	Calculated Standard Error (+/- dB)	Rounded Standard Error (+/- dB)
2	38.6	39
4	22.3	22
8	14.6	15
16	9.94	10
32	6.9	7
64	4.9	5
128	3.4	3
256	2.3	2
512	1.7	2
1024	.8<dB<1.7	1
2000	.8	1
2048	0<dB<.8	1

Table I

Stardard error for 99% confidence on received power values averaged over number of samples for standard deviation = 15 dB.

Fig. 19



AP Power adjust during STA movement

Fig. 20

AP Auction

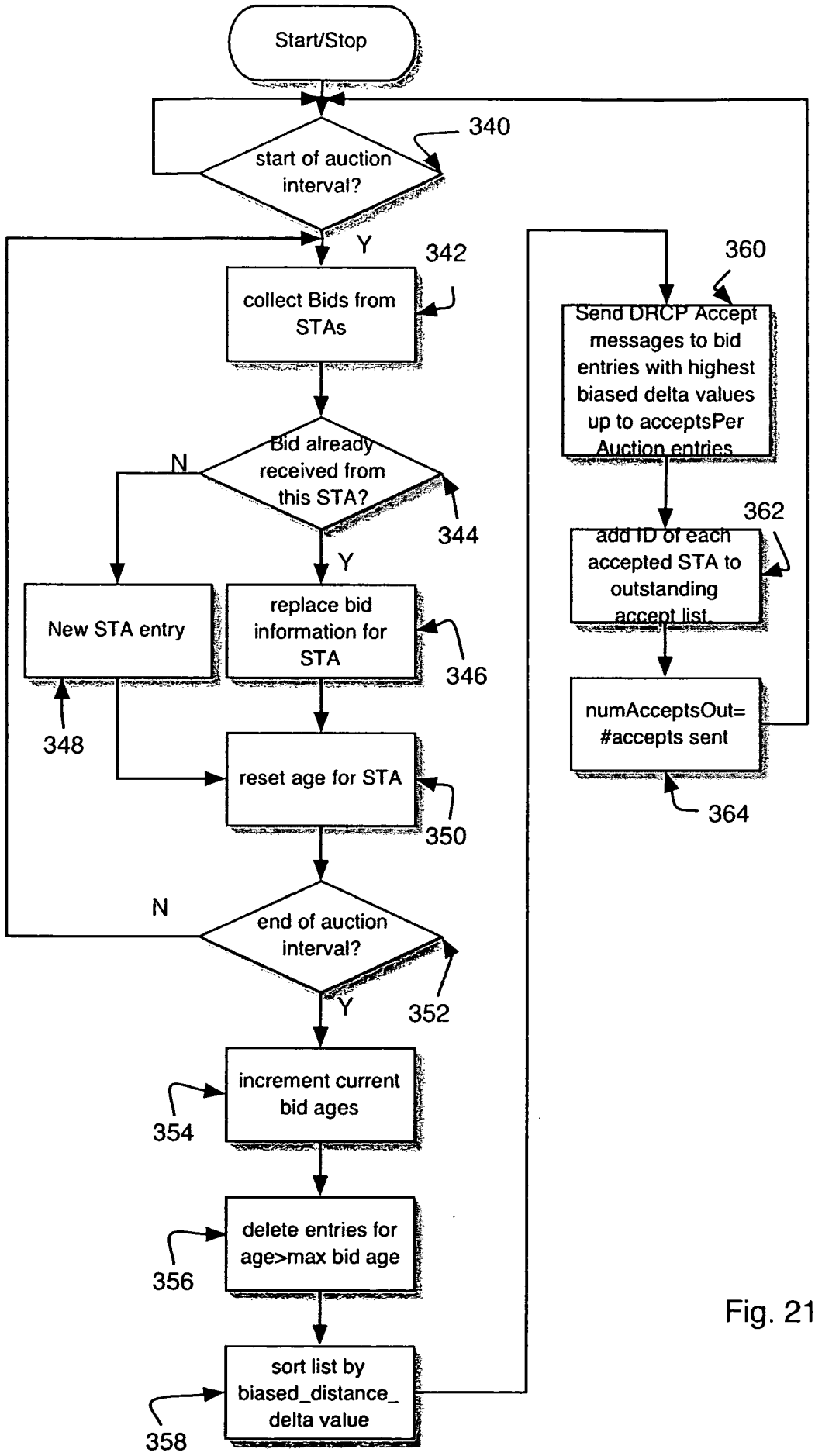


Fig. 21

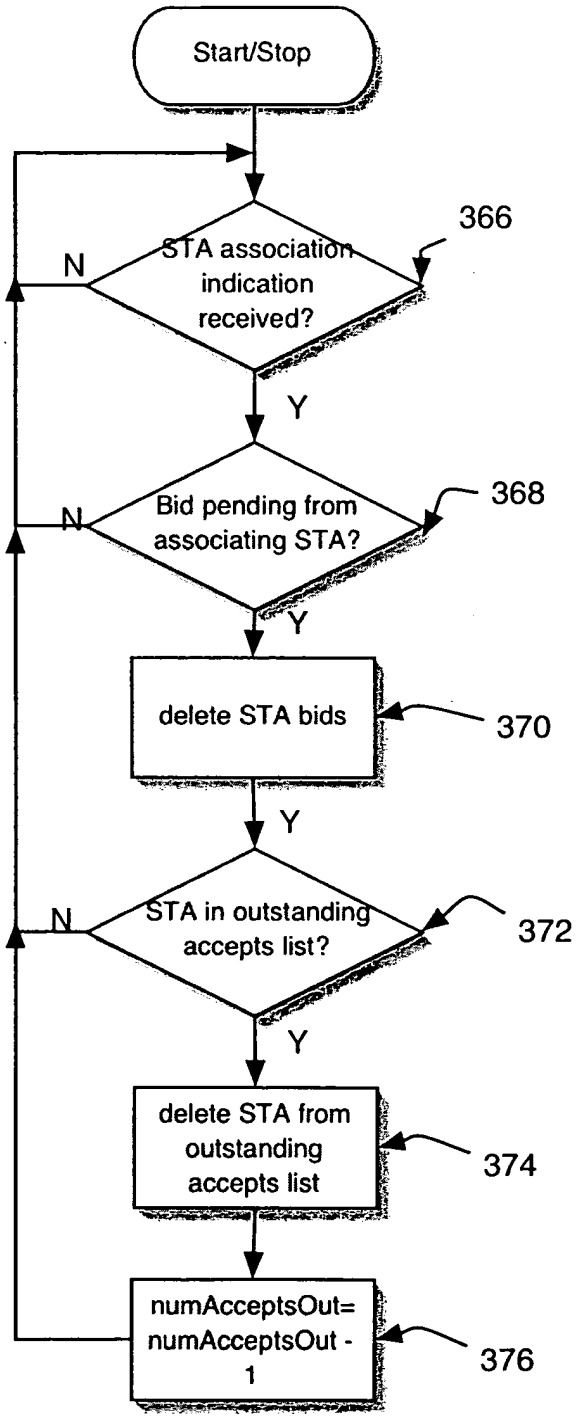

Start/Stop
366
STA association indication received?
N
Y
368
Bid pending from associating STA?
N
Y
delete STA bids
370
Y
372
STA in outstanding accepts list?
N
Y
delete STA from outstanding accepts list
374
numAcceptsOut= numAcceptsOut - 1
376

Fig. 22

STA Initialization

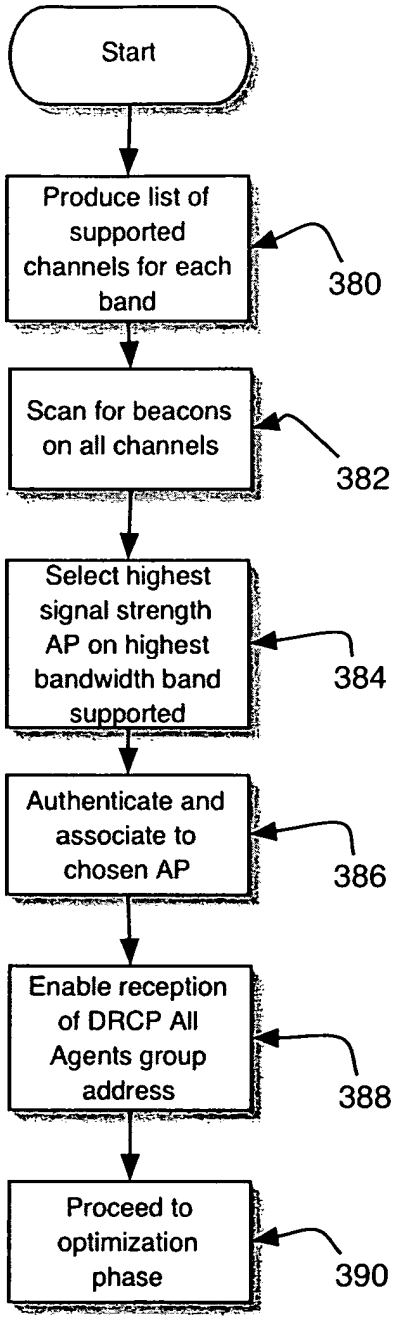


Fig. 23

STA Canvassing

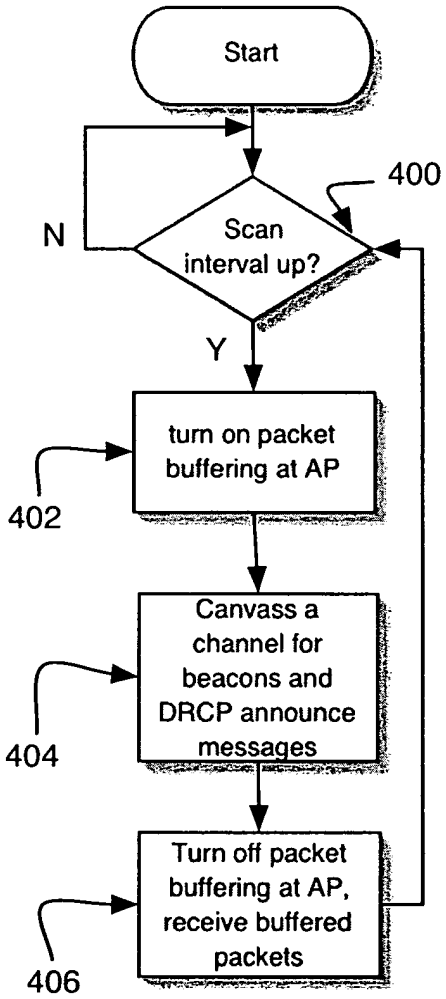


Fig. 24

STA Canvassing, 802.11

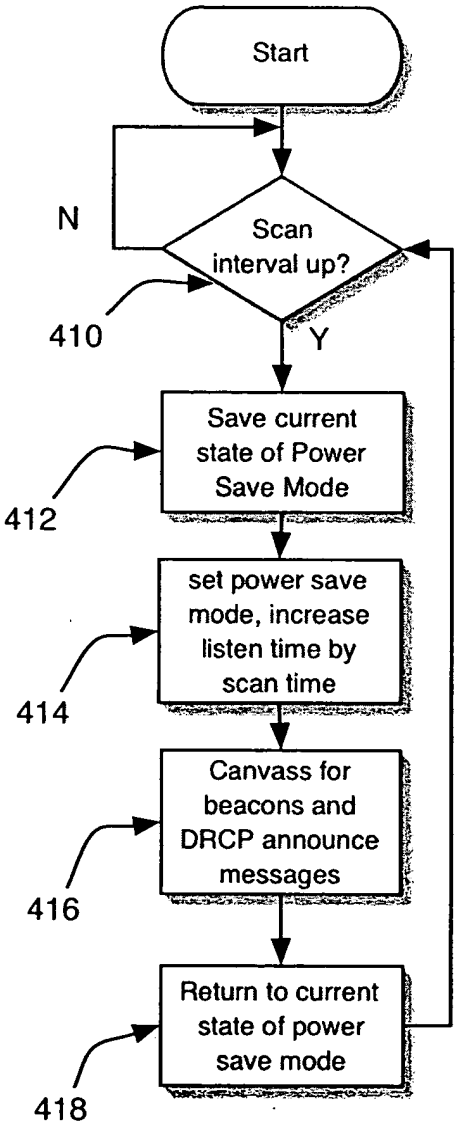


Fig. 25

430

AP_ID	Channel ID	age	Load Factor	TP Backoff	Max Power	distance _samples	distance	my_Load Factor	biased distance	corrected distance
AP[1]	3	2	2	<list>	<list>	10	avg	2	2	2
AP[2]	7	3	3	<list>	<list>	7		3	3	3
...	5	...	...	...	...	...	...	...	...	...
AP[MAX_AP]	2	1	1	<list>	<list>	13		1	1	1

STA Known APs Table

Fig. 26

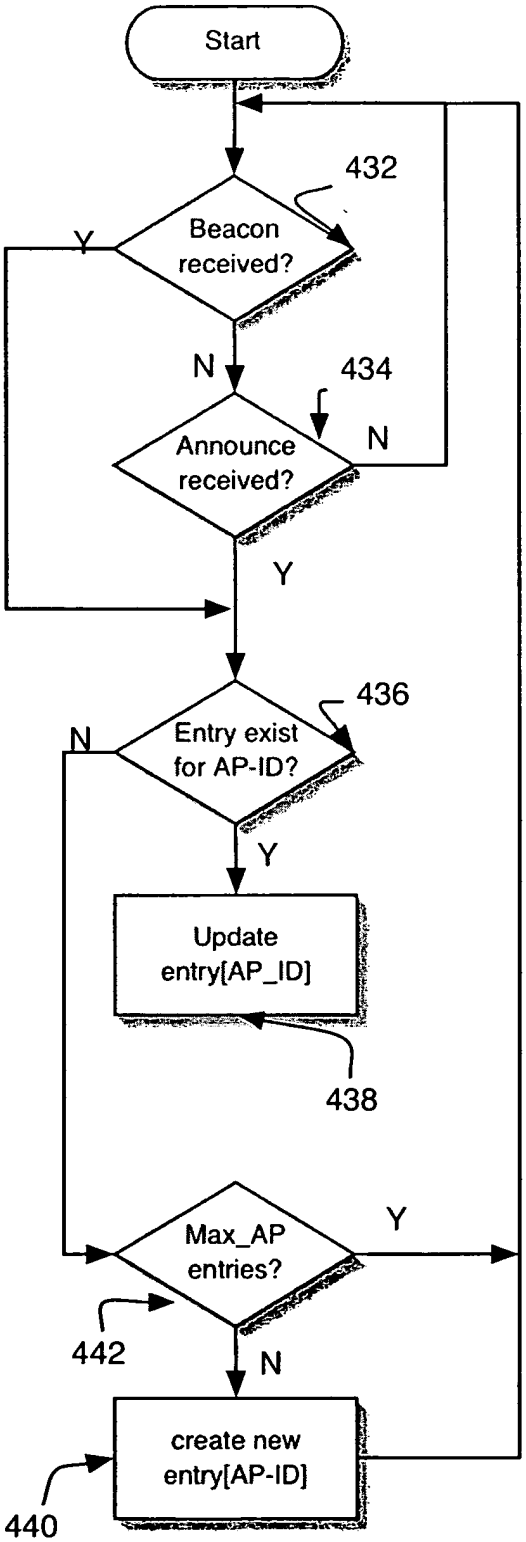

Start
432
Beacon received?
Y
N
434
Announce received?
N
Y
436
Entry exist for AP-ID?
N
Y
Update entry[AP_ID]
438
Max_AP entries?
Y
442
N
create new entry[AP-ID]
440

Fig. 27

STA Power Adjustment

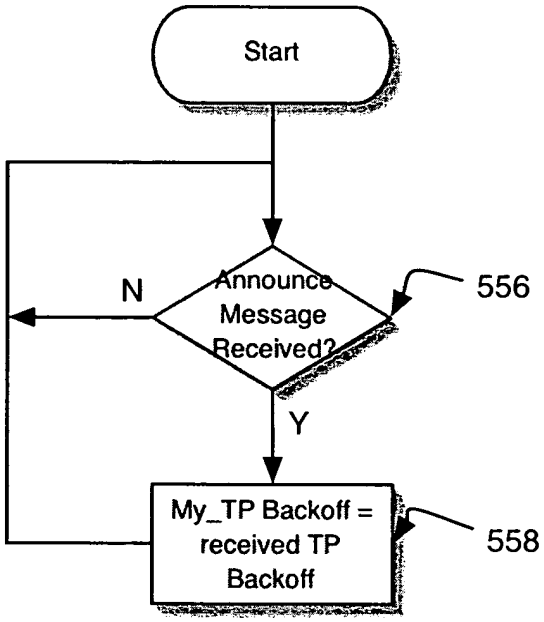


Fig. 28

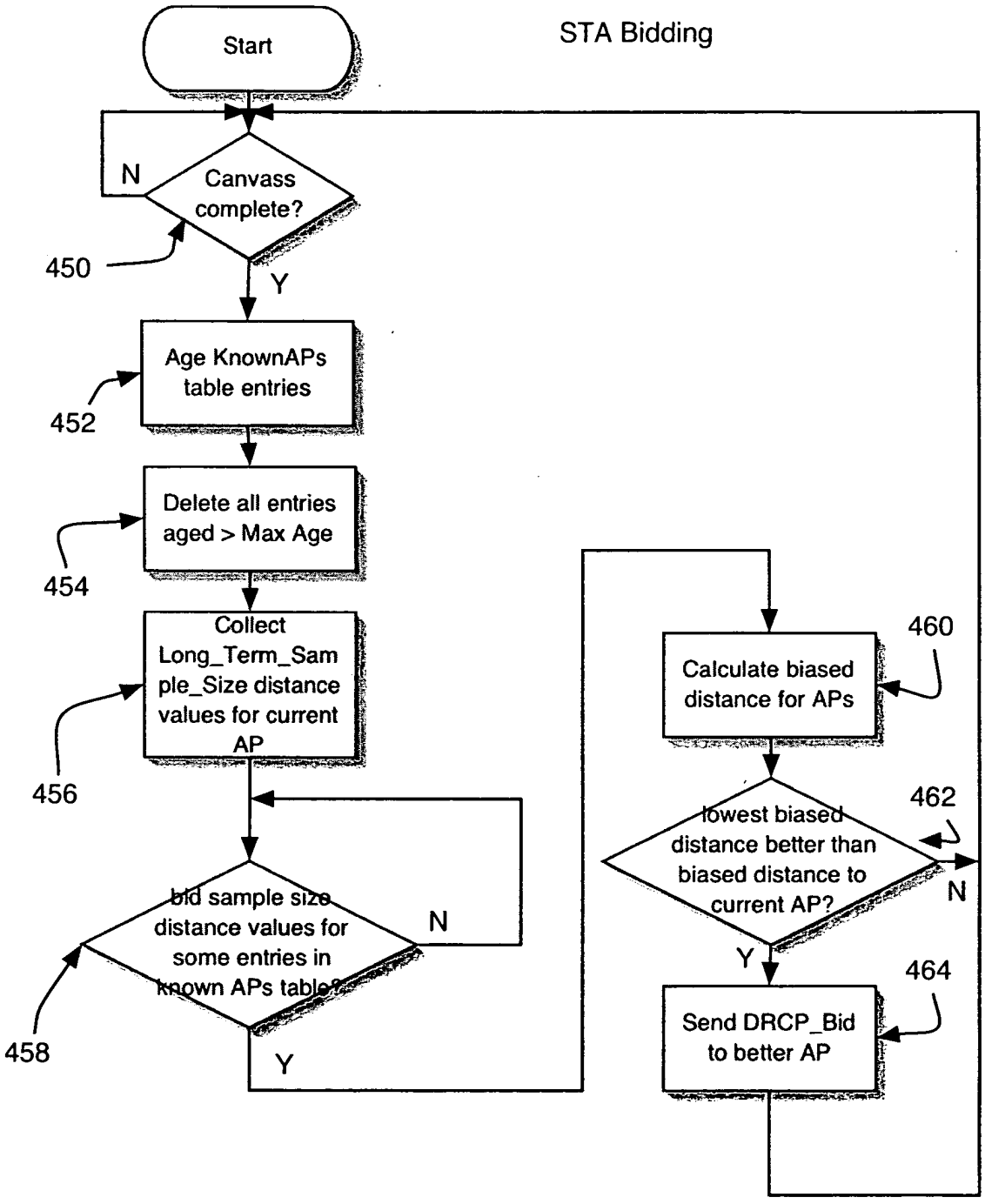

STA Bidding
Start
Canvass complete?
N
Y
450
Age KnownAPs table entries
452
Delete all entries aged > Max Age
454
Collect Long_Term_Sample_Size distance values for current AP
456
bid sample size distance values for some entries in known APs table?
N
Y
458
Calculate biased distance for APs
460
lowest biased distance better than biased distance to current AP?
462
N
Y
Send DRCP_Bid to better AP
464

Fig. 29

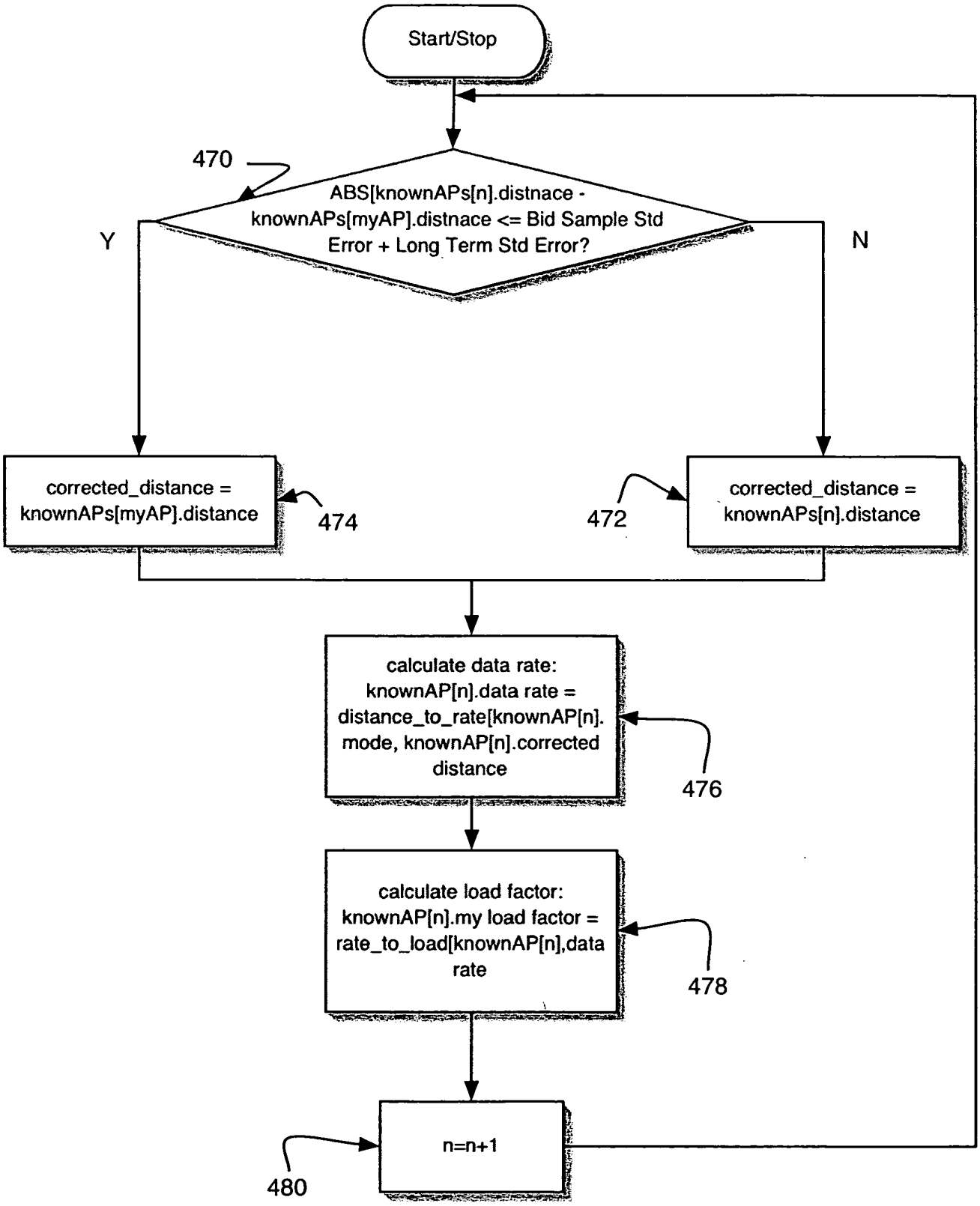

Start/Stop
470
ABS[knownAPs[n].distnace - knownAPs[myAP].distnace <= Bid Sample Std Error + Long Term Std Error?
Y
N
corrected_distance = knownAPs[myAP].distance
474
472
corrected_distance = knownAPs[n].distance
calculate data rate: knownAP[n].data rate = distance_to_rate[knownAP[n]. mode, knownAP[n].corrected distance
476
calculate load factor: knownAP[n].my load factor = rate_to_load[knownAP[n],data rate
478
n=n+1
480

Fig. 30

Distance in Banzais	802.11a, g Mb/s	802.11b Mb/s
0-68	54	11
69-72	48	11
73-76	36	11
77-80	24	11
81-83	18	11
84-85	12	5.5
86	9	5.5
87	9	2
88	6	2
89	2	2
90-91	2	1
92-94	1	0
95-97	.5	0

Table II

Distance_to_Rate Table, 802.11

Fig. 31

Data Rate	Load Factor
108	4
72	6
54	8
48	9
36	12
24	18
18	24
11	39
9	48
6	72
5.5	79
2	216
1	432
.5	864
0	65,535

Table III

Rate_to_Load table for 802.11

Fig. 32

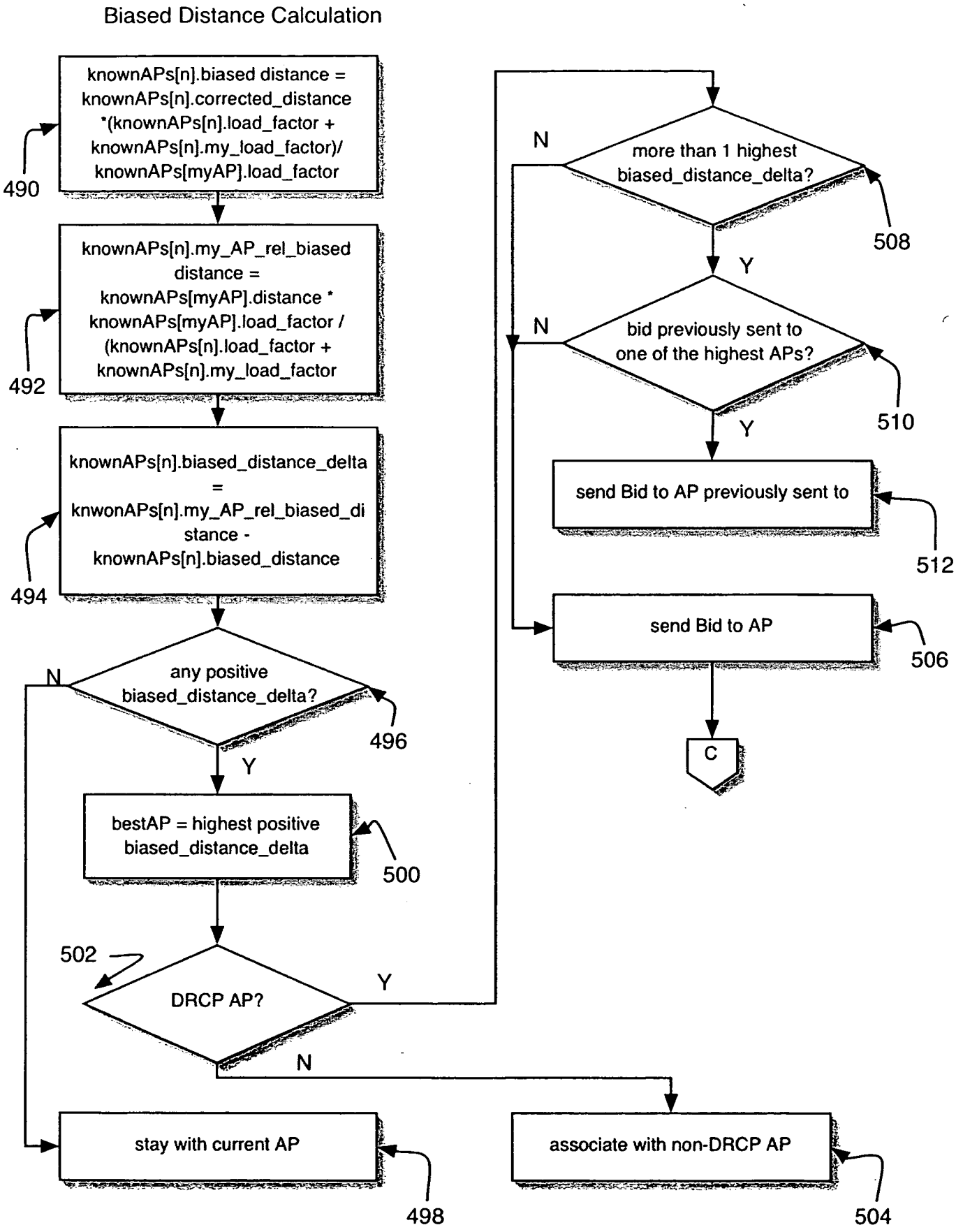

Biased Distance Calculation
knownAPs[n].biased distance = knownAPs[n].corrected_distance *(knownAPs[n].load_factor + knownAPs[n].my_load_factor)/ knownAPs[myAP].load_factor
490
knownAPs[n].my_AP_rel_biased distance = knownAPs[myAP].distance * knownAPs[myAP].load_factor / (knownAPs[n].load_factor + knownAPs[n].my_load_factor
492
knownAPs[n].biased_distance_delta = knwonAPs[n].my_AP_rel_biased_distance - knownAPs[n].biased_distance
494
any positive biased_distance_delta?
N
Y
496
bestAP = highest positive biased_distance_delta
500
502
DRCP AP?
Y
N
stay with current AP
498
associate with non-DRCP AP
504
more than 1 highest biased_distance_delta?
N
Y
508
bid previously sent to one of the highest APs?
N
Y
510
send Bid to AP previously sent to
512
send Bid to AP
506
C

Fig. 33A

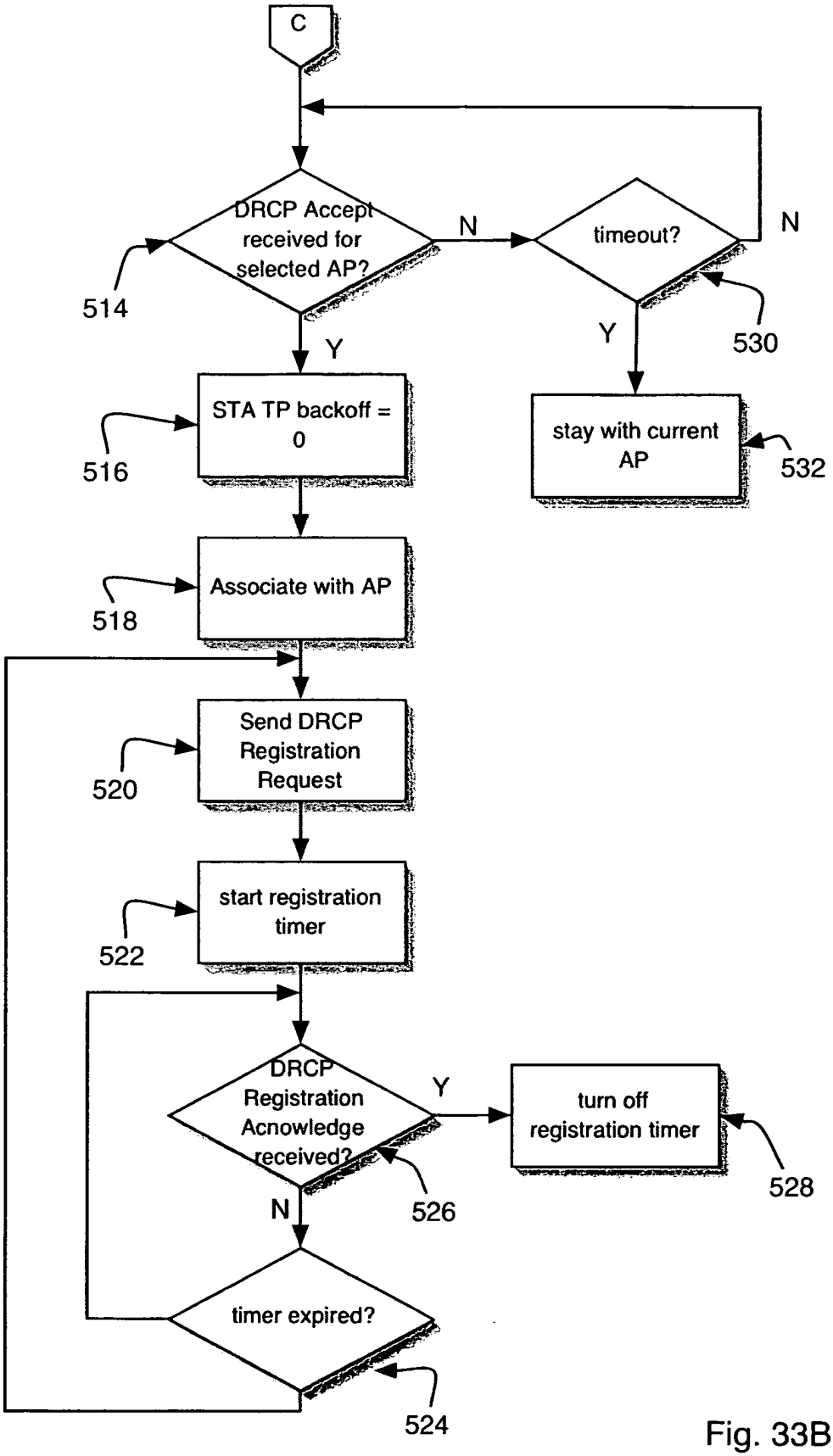

C
DRCP Accept received for selected AP?
514
N
timeout?
N
530
Y
Y
STA TP backoff = 0
516
stay with current AP
532
Associate with AP
518
Send DRCP Registration Request
520
start registration timer
522
DRCP Registration Acnowledge received?
526
Y
turn off registration timer
528
N
timer expired?
524

Fig. 33B

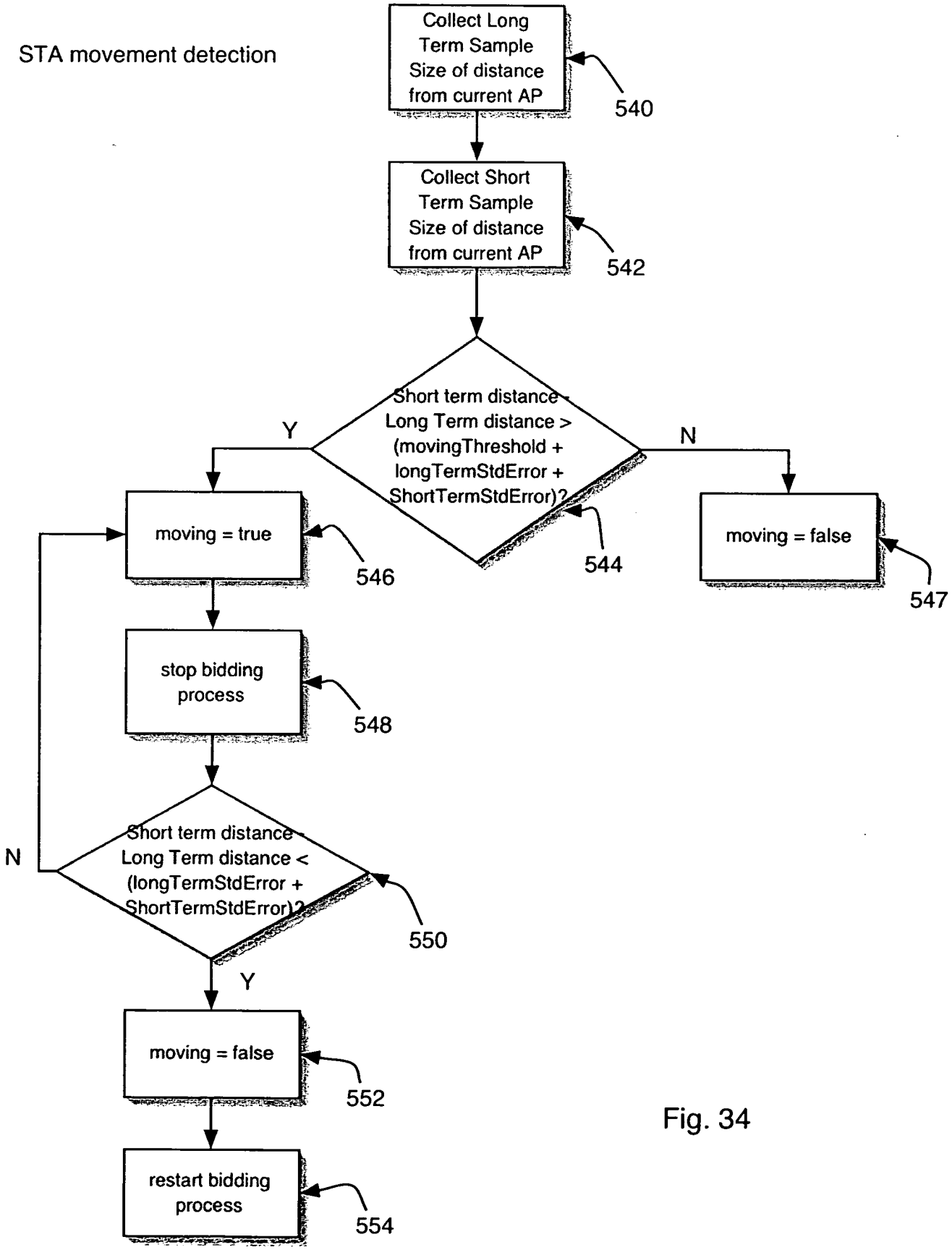

STA movement detection
Collect Long Term Sample Size of distance from current AP
540
Collect Short Term Sample Size of distance from current AP
542
Short term distance - Long Term distance > (movingThreshold + longTermStdError + ShortTermStdError)?
544
Y
N
moving = true
546
moving = false
547
stop bidding process
548
Short term distance - Long Term distance < (longTermStdError + ShortTermStdError)?
550
N
Y
moving = false
552
restart bidding process
554

Fig. 34

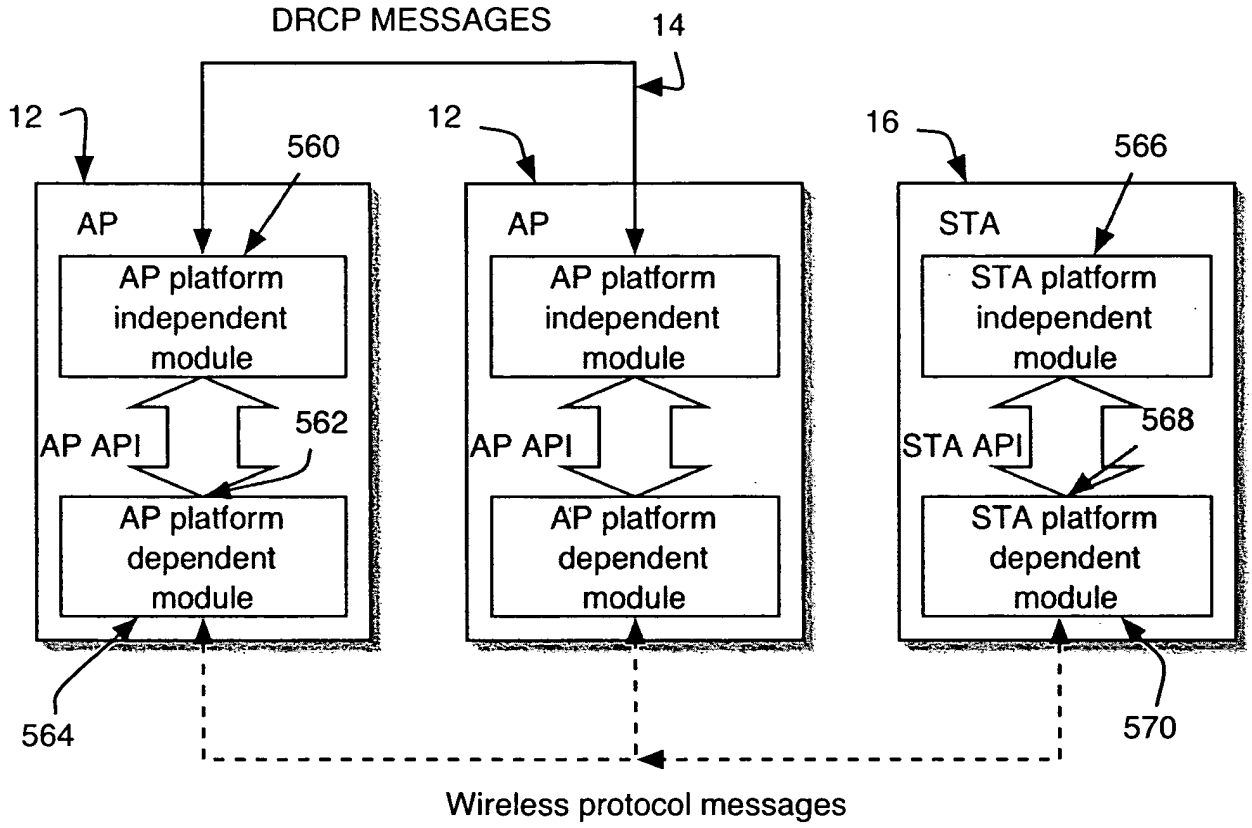

DRCP MESSAGES
14
12
560
AP
AP platform independent module
AP API
562
AP platform dependent module
564
12
AP
AP platform independent module
AP API
AP platform dependent module
16
566
STA
STA platform independent module
STA API
568
STA platform dependent module
570
Wireless protocol messages

Fig. 35

802.11 AP DRCP Architecture

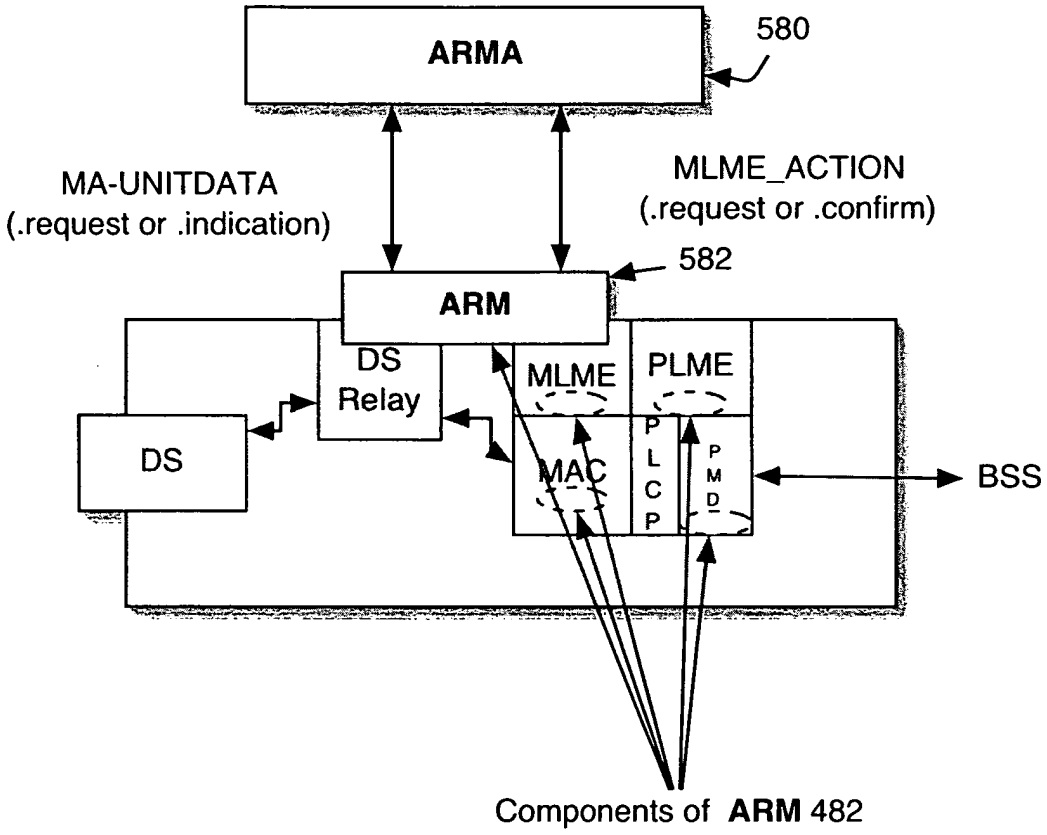


Fig. 36

802.11 STA DRCP Architecture

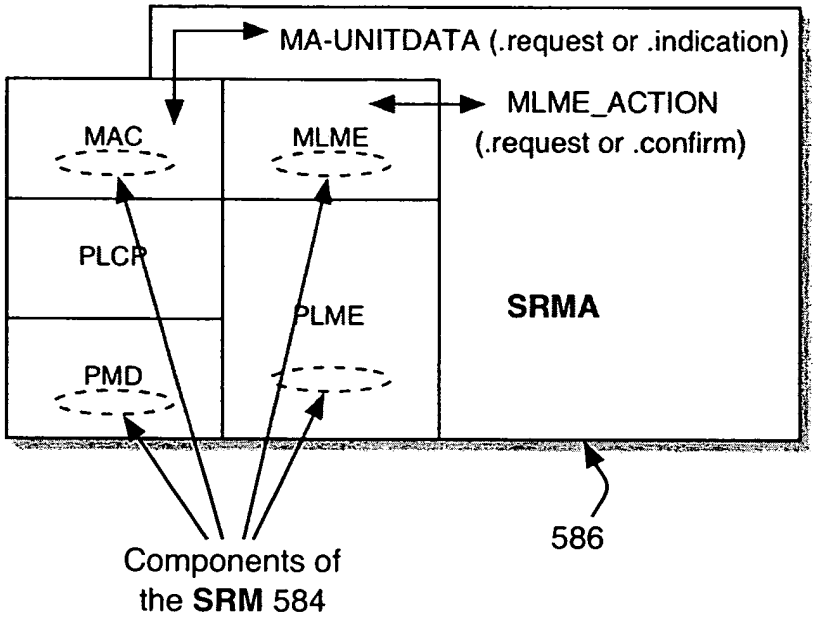


Fig. 37

Encoding of DRCP Message in an 802.11 Management Frame of Subtype Beacon

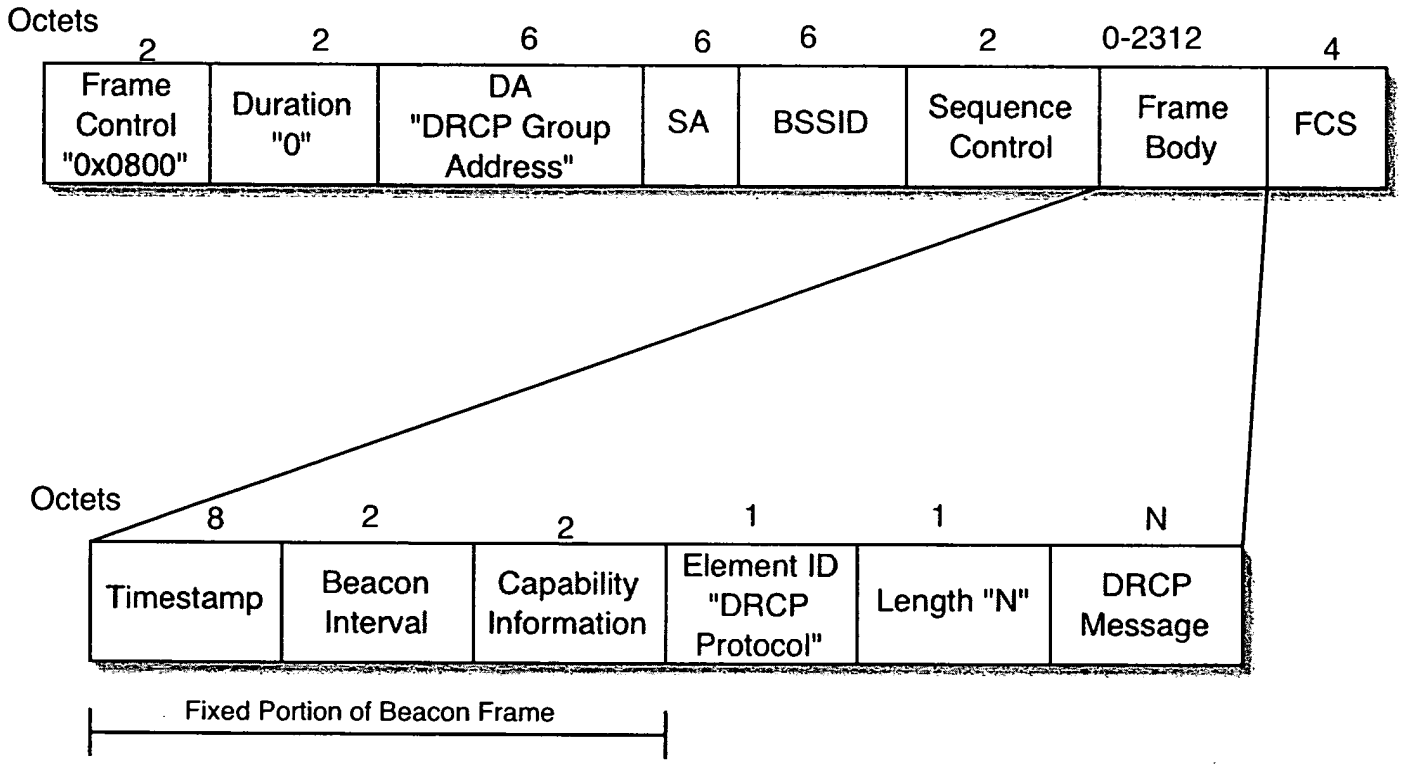


Fig. 38

Encoding of DRCP Message in an 802.11 Data Frame

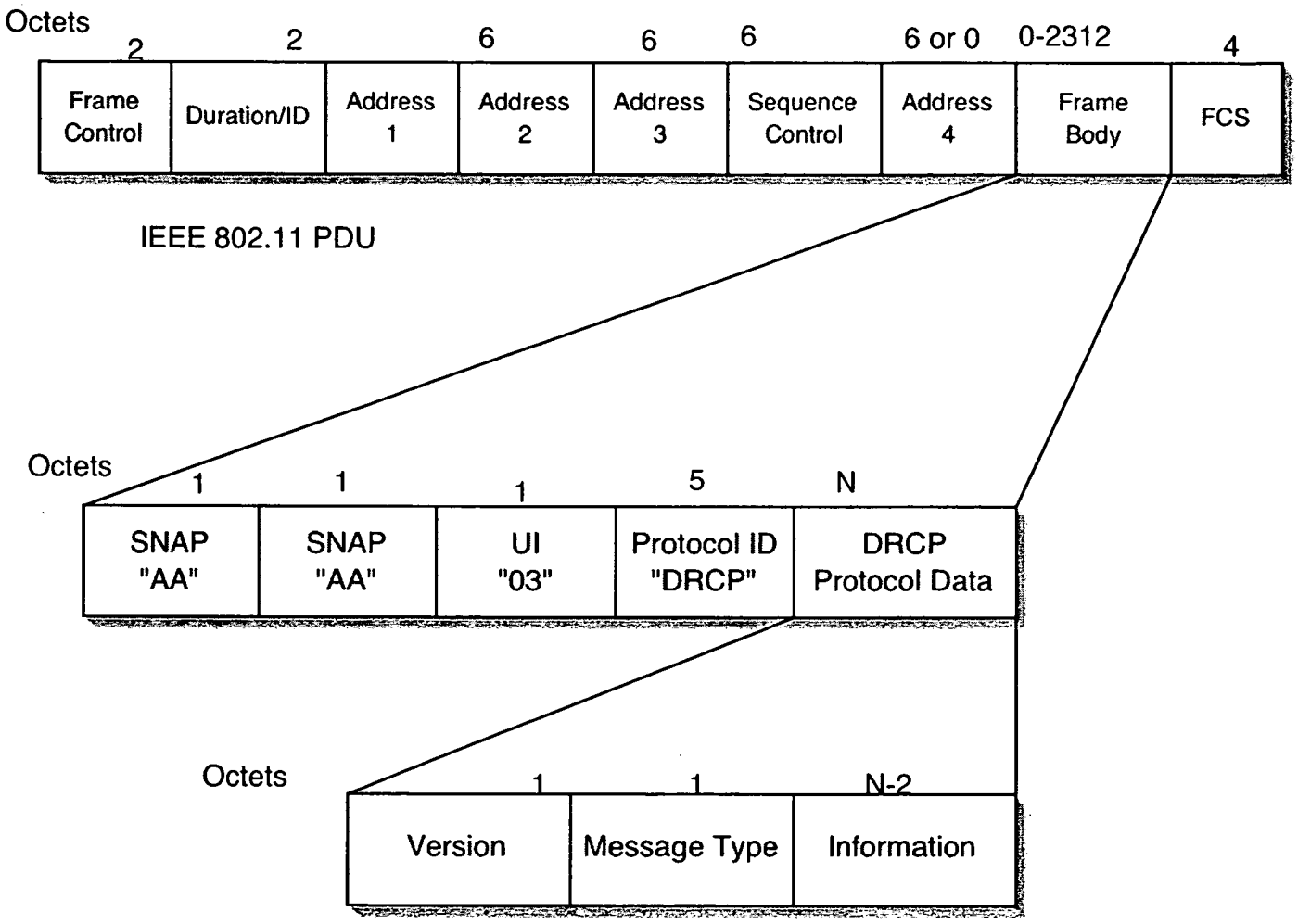


Fig. 39

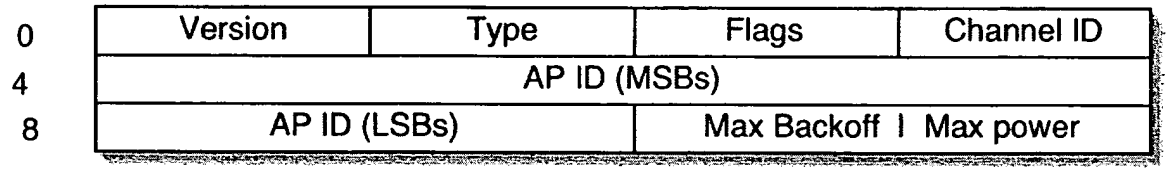
Message Type	Usage	Data Rate	Max Power
DRCP Preclaim	Used by ARMAs in the channel selection process	Lowest Datarate	Max Power
DRCP Claim	Used by ARMAs in the channel selection process	Lowest Datarate	Max Power
DRCP Announce	Used by ARMAs to announce their presence to SRMAs and other ARMAs.	Lowest Datarate	Max Power
DRCP Bid	Used by SRMAs to bid for slots on ARMAs	STA Datarate	Max Power - TP Backoff
DRCP Accept	Used by ARMAs to signal to SRMAs permission to associate	STA Datarate	Max Power - TP Backoff
DRCP Registration Request	Used by STAs to tell ARMAs they will associate	STA Datarate	Max Power - TP Backoff
DRCP Registration Acknowledge	Used by ARMAs to tell STA it received registration request	STA Datarate	Max Power - TP Backoff

Fig. 40

Name	Size	Description
Type	1	Message type. Values: 1 = DRCP Claim 2 = DRCP Announce 3 = DRCP Preclaim 4 = DRCP Bid 5 = DRCP Accept 6 = DRCP Registration Request 7 = DRCP Registration Acknowledge
Channel ID	1	Indicates the channel of the originating station
AP-ID	6	The MAC Address of the AP in which the transmitting ARMA is insantiated
SSID	32	The Service Set ID (SSID) of the AP in which the transmitting ARMA is instantiated. This value is also referred to as the "Network Name".
Load Factor	2	The sum of the loads of the ATAs currently associated to the transmitting AP.
TP Backoff	2	Transmit power backoff value in use by the transmitting AP.
Max Power	2	Maximum pwer output, in dBm, of the transmitting AP's radio.
Biased Distance Delta	4	The difference between the biased distance from the transmitting STA to its current AP and the destination AP.
STA ID	6	The MAC address of the STA in which the transmitting SRMA is instantiated.
STA Assoc AP ID	6	The MAC address of the AP to which the transmitting STA is currently associated.
Bid AP ID	6	The MAC address of the AP to which the transmitting STA is bidding.
Accepted STA ID	6	The MAC address of the STA that the sending AP is accepting.
STA Reported AP ID	6	The MAC address of the AP that was identified in the last Bid message as the accepted STA's associated AP.
Max TP Backoff	2	Max dB's backoff capable of an AP
Adjacency Vector Sum	2	Sum of received power levels from all APs heard during scanning and preclaiming.

Fig. 41

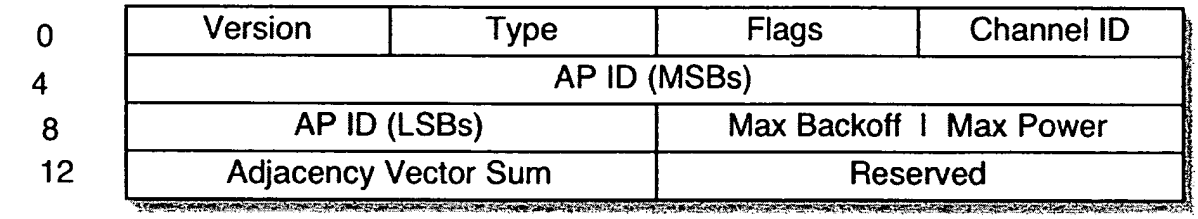
Byte Address



DRCP Preclaim Message

Fig. 42

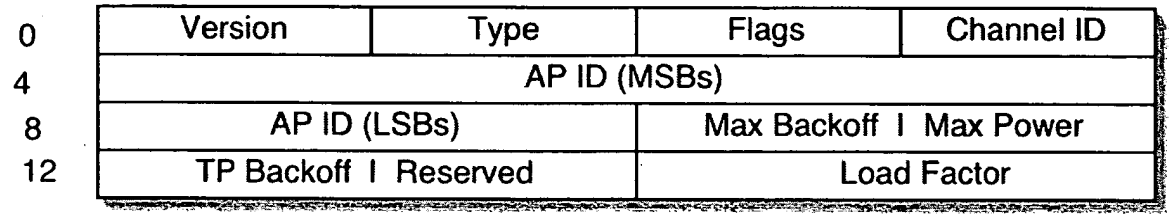
Byte Address



DRCP Claim Message

Fig. 43

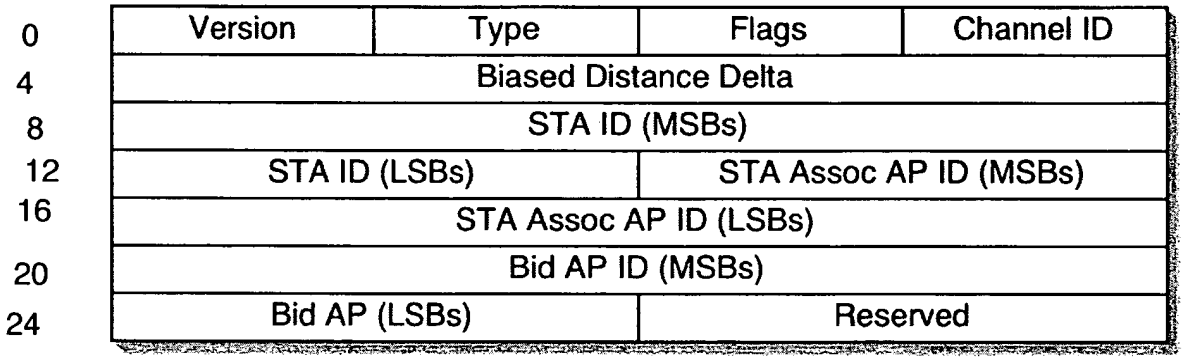
Byte Address



DRCP Announce Message

Fig. 44

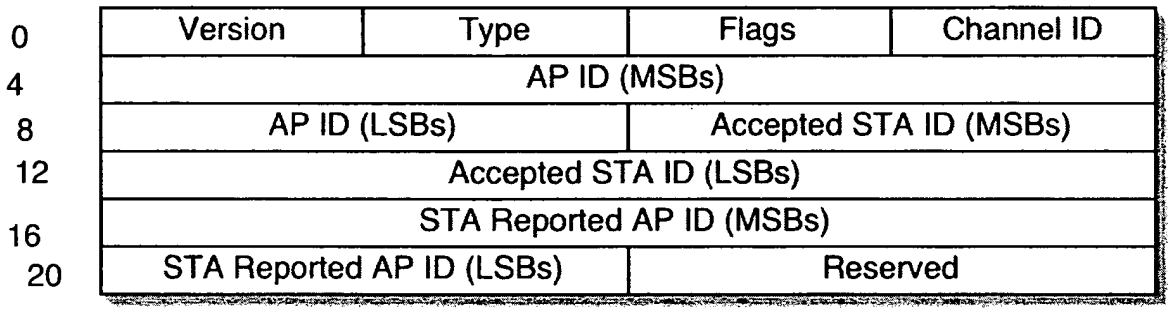
Byte Address



DRCP Bid Message

Fig. 45

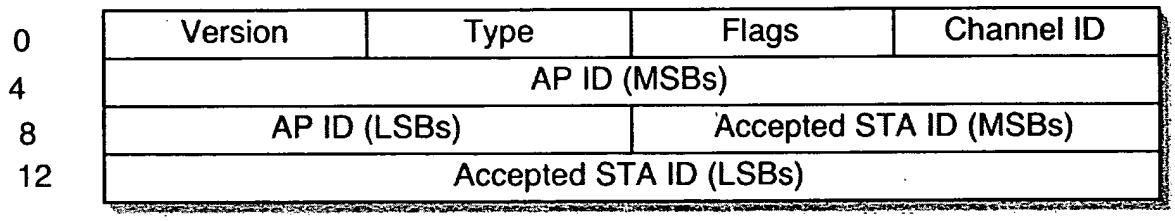
Byte Address



DRCP Accept Message

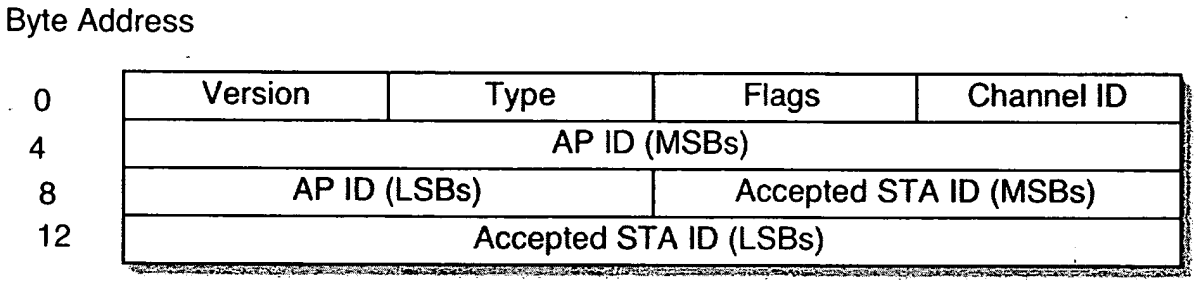
Fig. 46

Byte Address



DRCP Registration Request Message

Fig. 47



DRCP Registration Acknowledge Message

Fig. 48

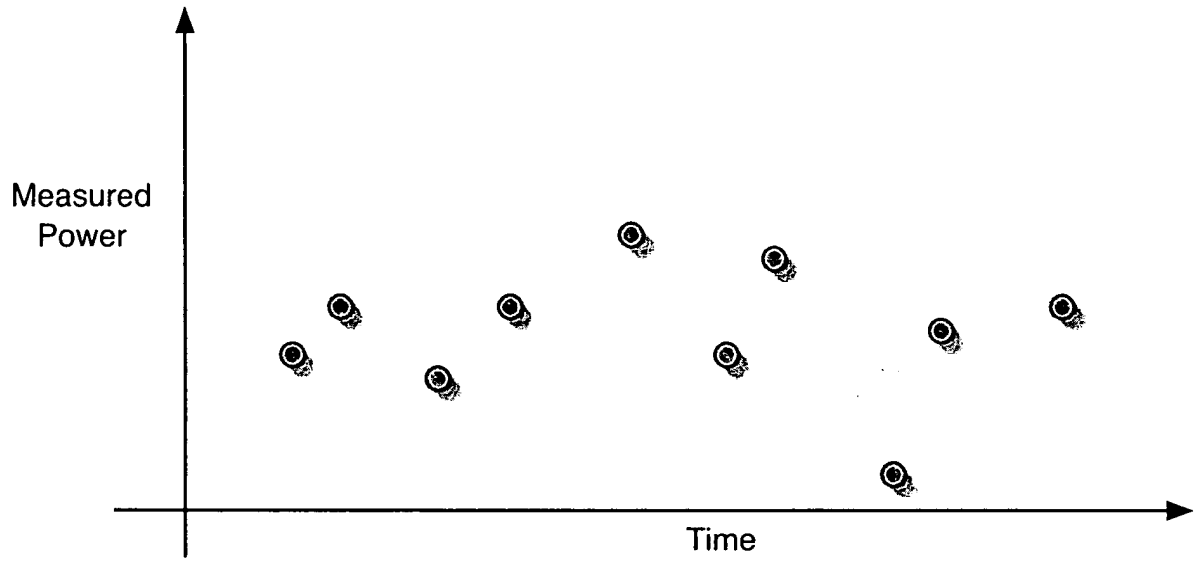


Fig. 49

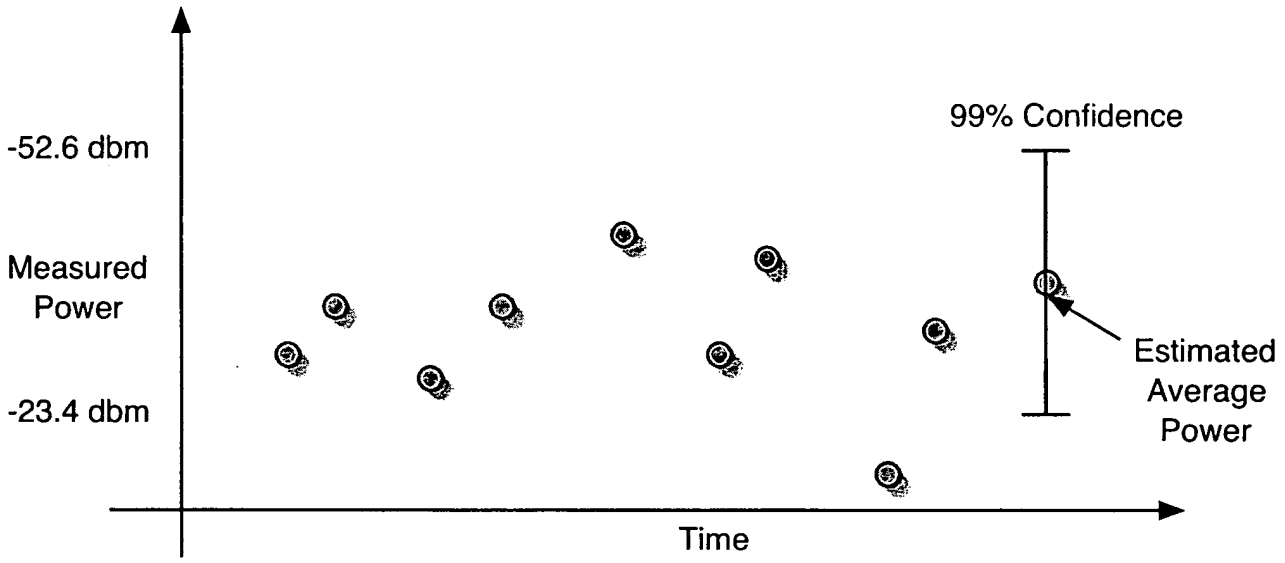

-52.6 dbm
Measured
Power
-23.4 dbm
Time
99% Confidence
Estimated
Average
Power

Fig. 50

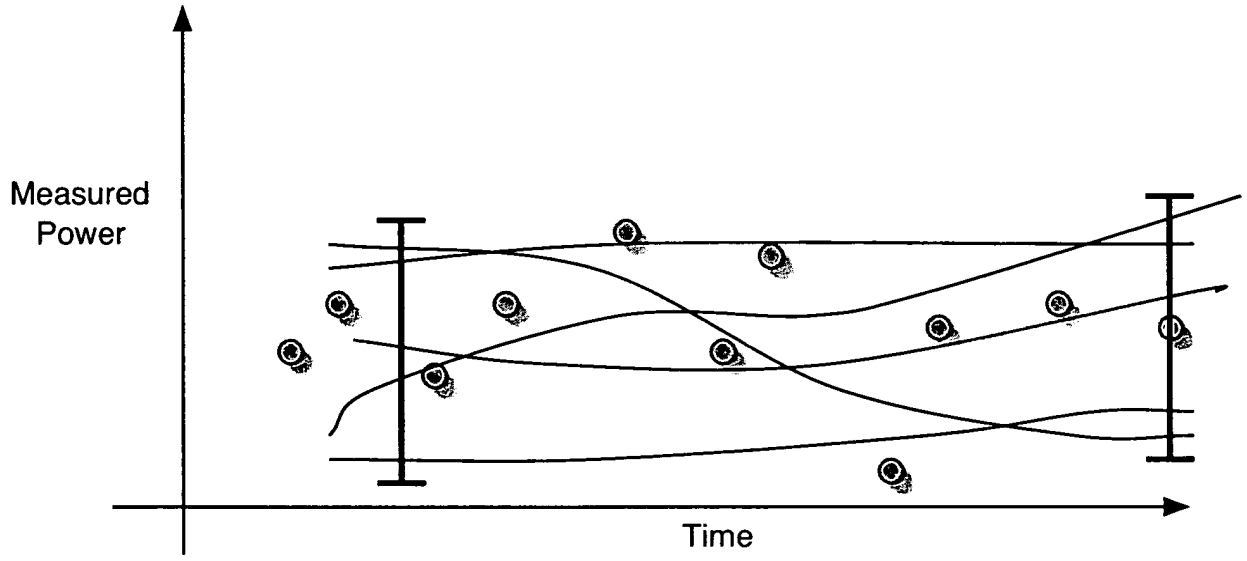


Fig. 51

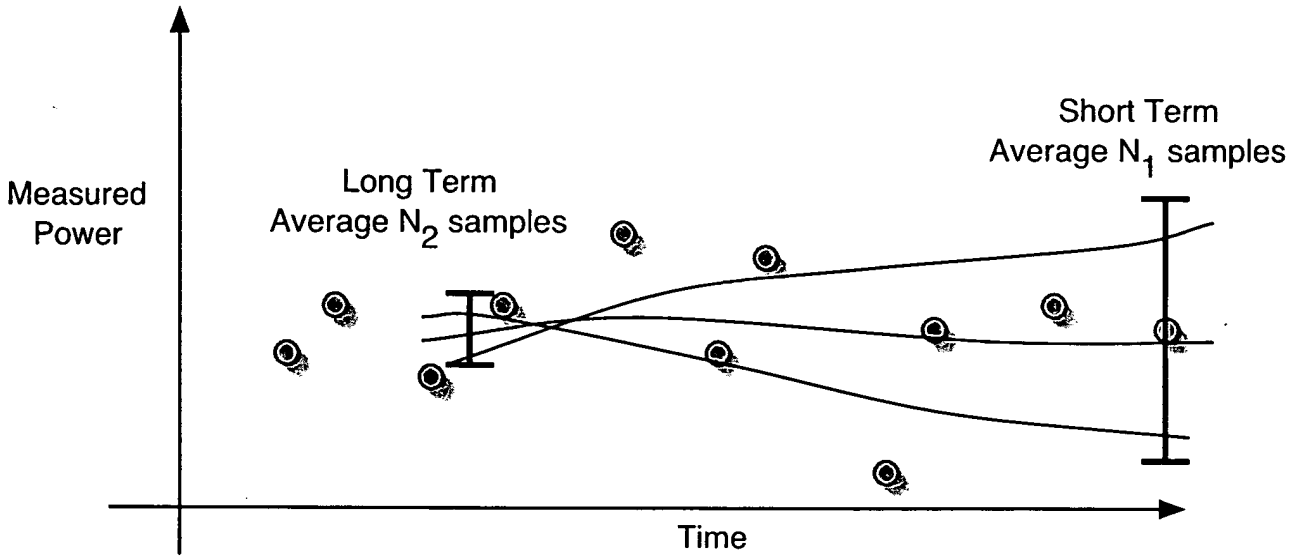

Measured
Power
Long Term
Average N_2 samples
Short Term
Average N_1 samples
Time

Fig. 52

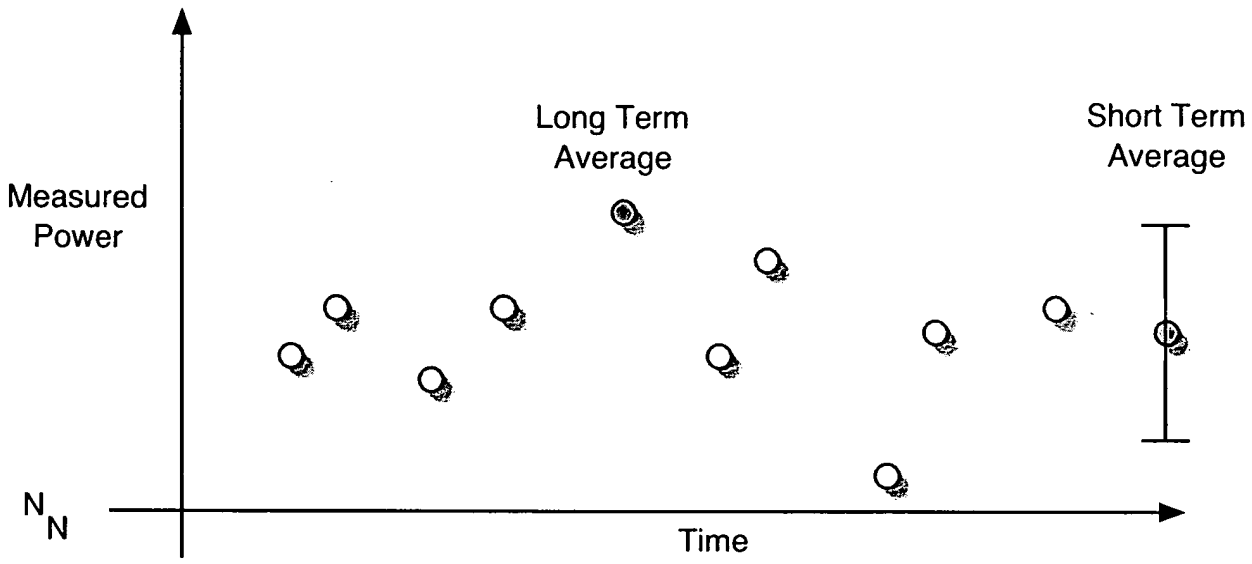

Long Term
Average
Short Term
Average
Measured
Power
N
N
Time

Fig. 53

Sample Time Duration	# Power Samples (N2)	Upper 99% Confidence Interval	Lower 99% Confidence Interval
1 sec	20	-29.1 dbm	-46.9 dbm
10 sec	200	-35.3 dbm	-40.7 dbm
100 sec	2000	-37.2 dbm	-38.3 dbm
1000 sec	20,000	-37.7 dbm	-38.3 dbm

Fig. 54

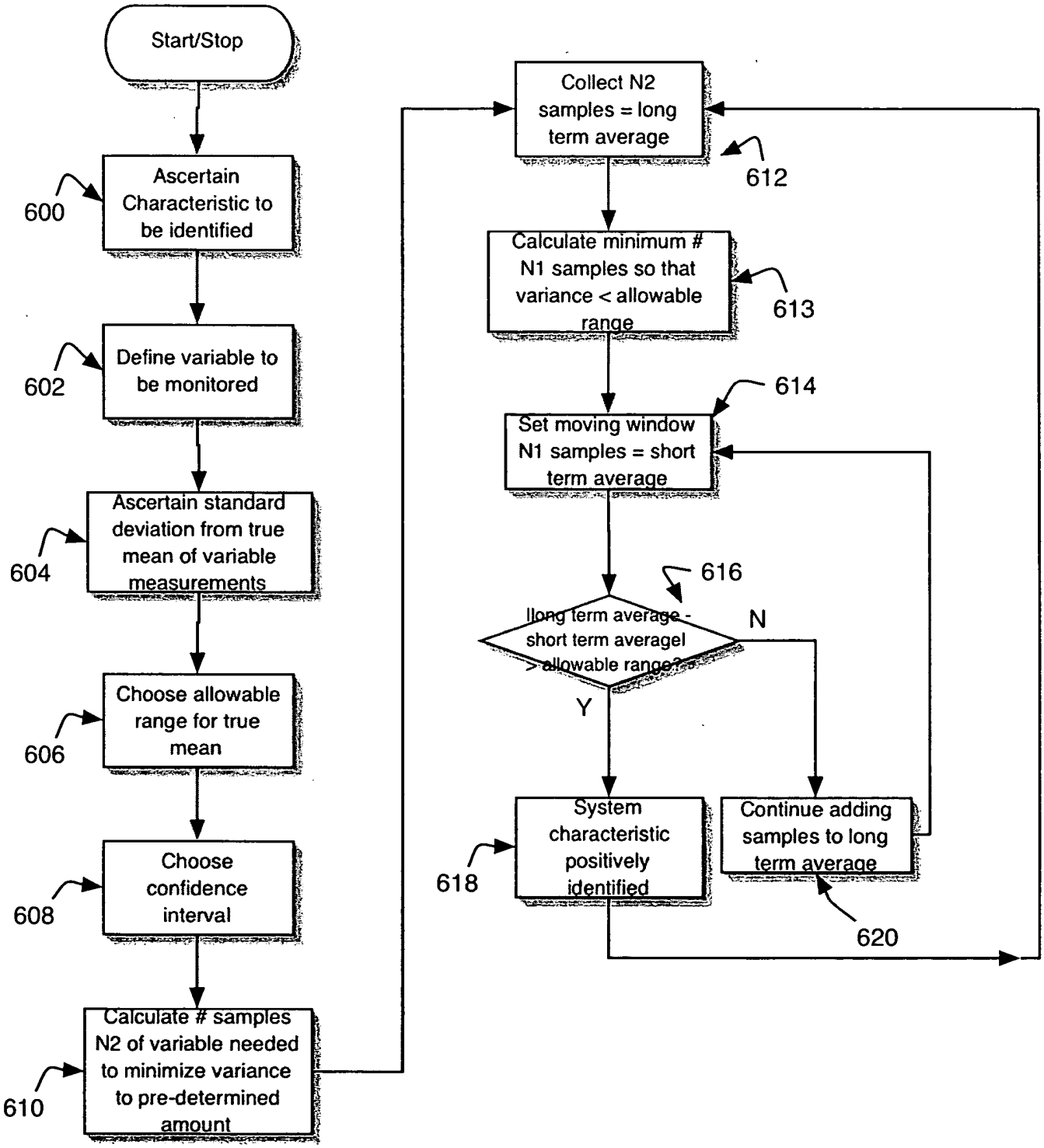

Start/Stop
Ascertain Characteristic to be identified
600
Define variable to be monitored
602
Ascertain standard deviation from true mean of variable measurements
604
Choose allowable range for true mean
606
Choose confidence interval
608
Calculate # samples N2 of variable needed to minimize variance to pre-determined amount
610
Collect N2 samples = long term average
612
Calculate minimum # N1 samples so that variance < allowable range
613
614
Set moving window N1 samples = short term average
616
|long term average - short term average| > allowable range?
N
Y
System characteristic positively identified
618
Continue adding samples to long term average
620

Fig. 55

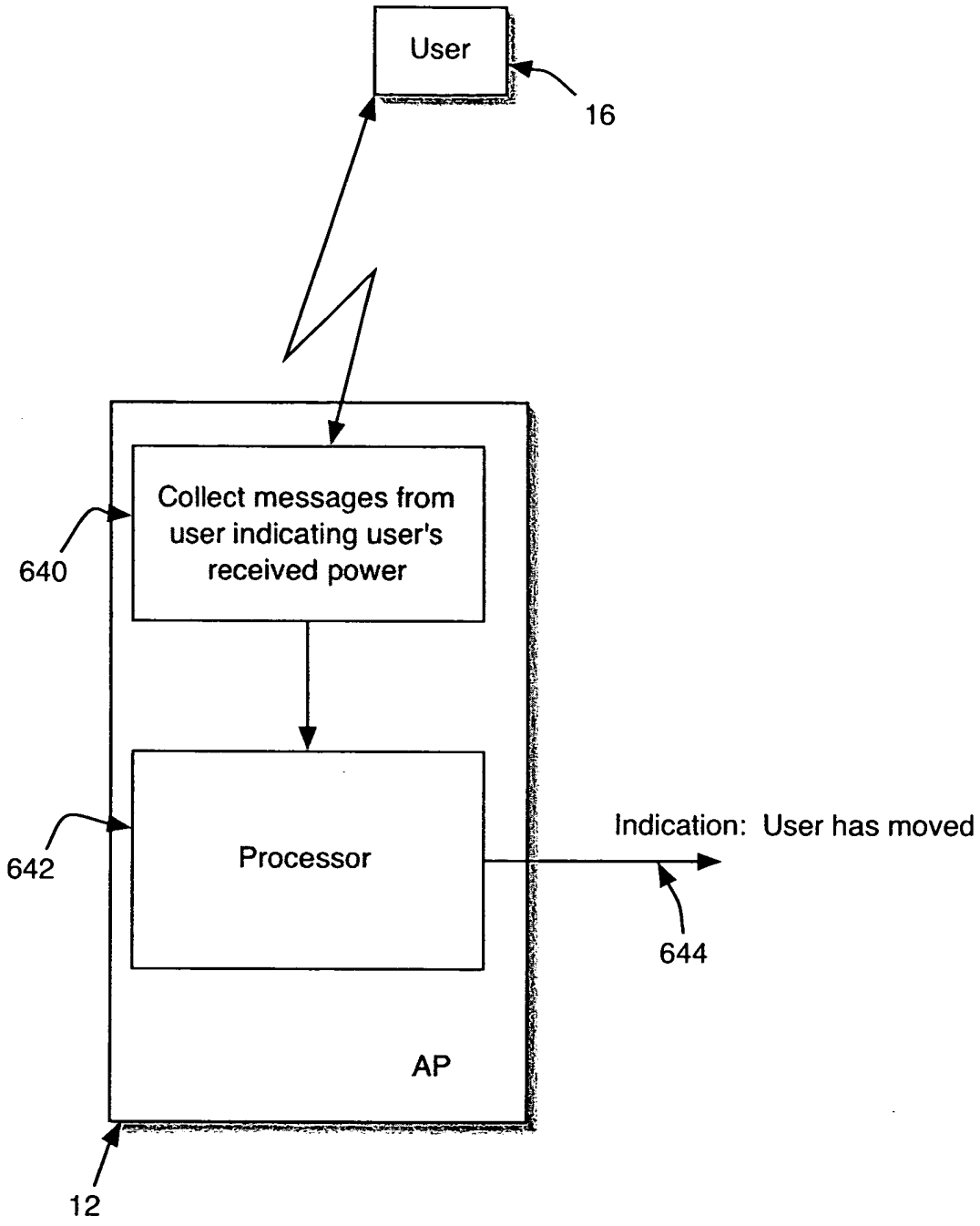

User
16
Collect messages from user indicating user's received power
640
Processor
642
Indication: User has moved
644
AP
12

Fig. 56

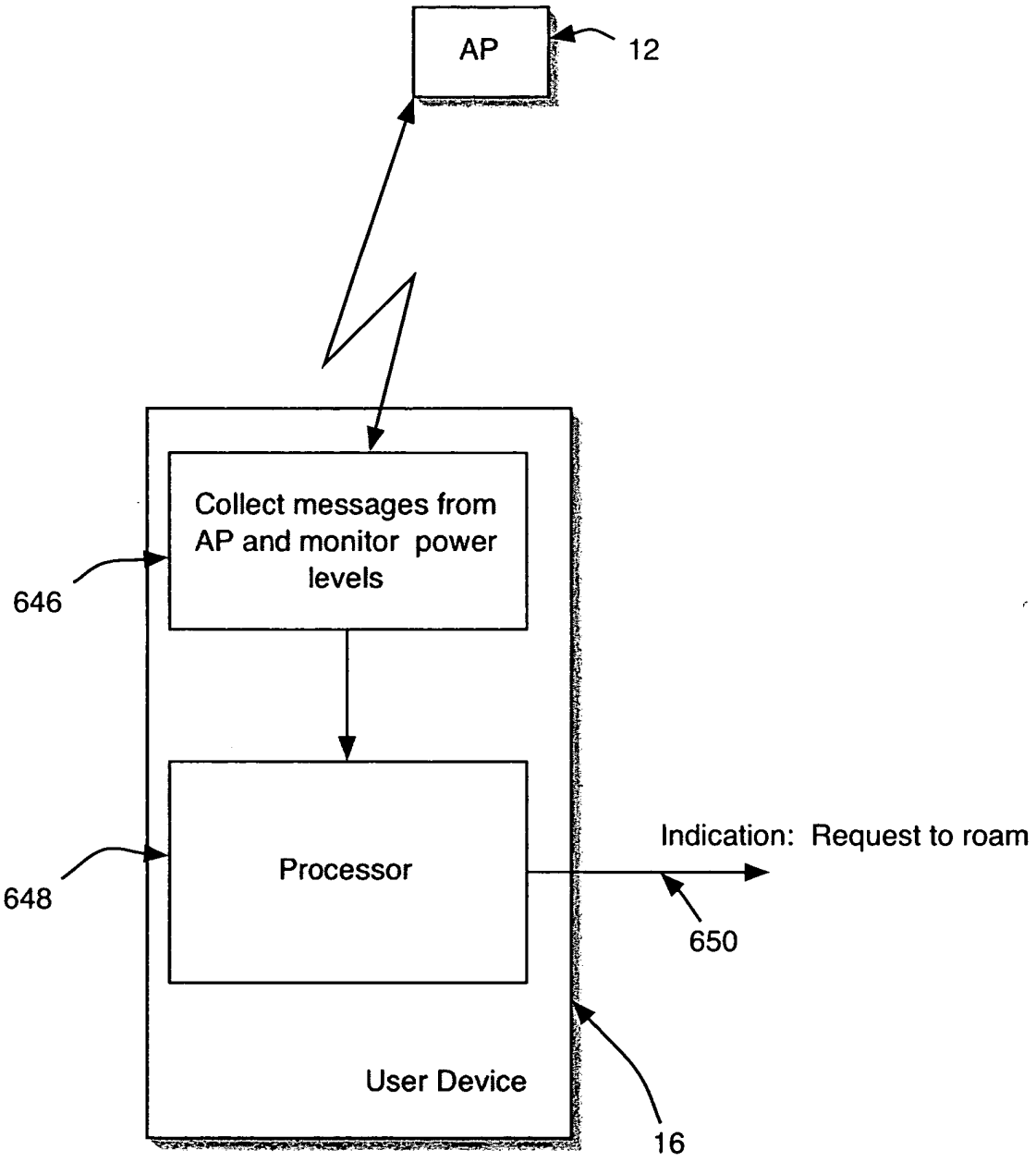

AP
12
Collect messages from AP and monitor power levels
646
Processor
648
Indication: Request to roam
650
User Device
16

Fig. 57

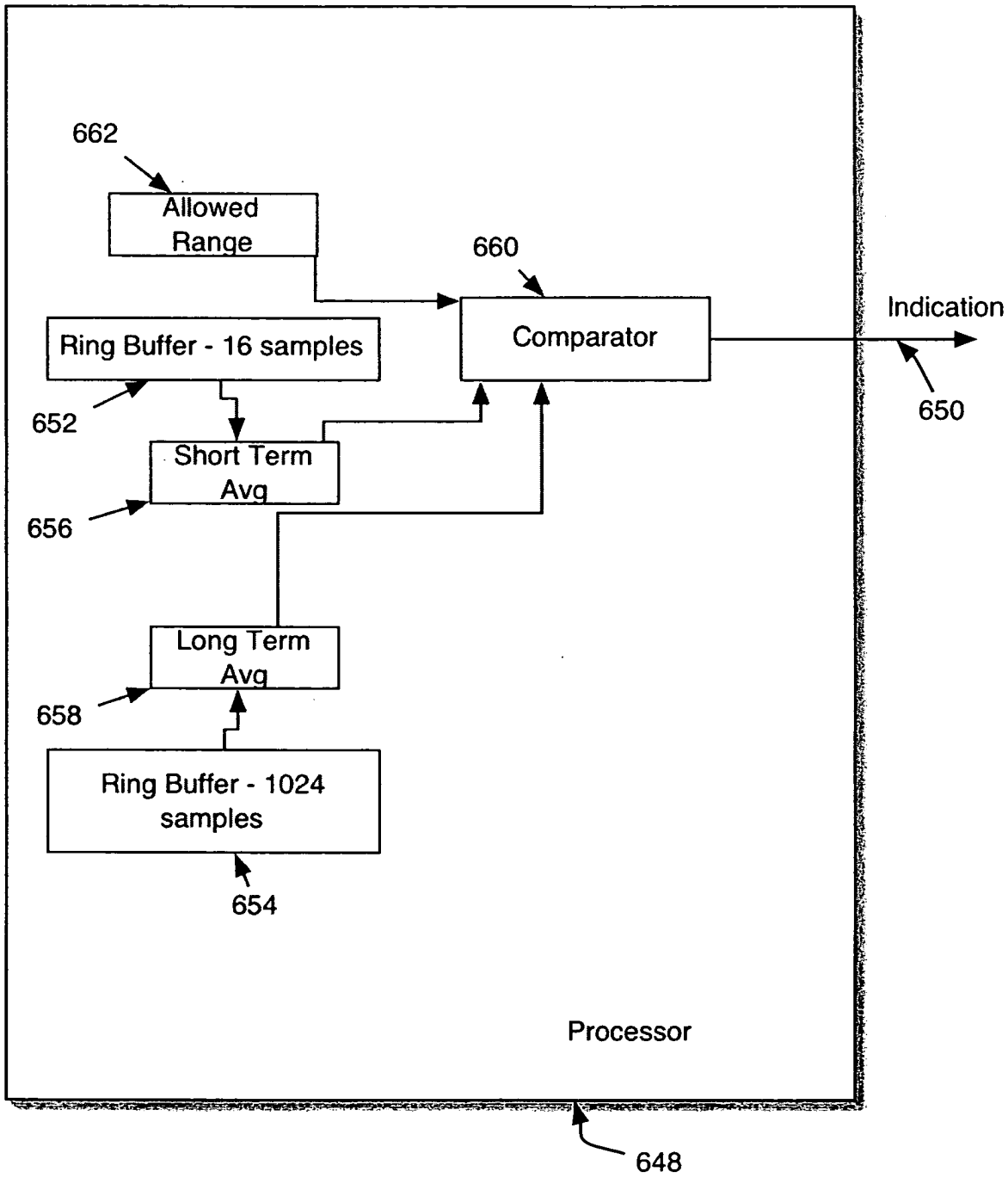

662
Allowed Range
660
Comparator
Indication
Ring Buffer - 16 samples
650
652
Short Term Avg
656
Long Term Avg
658
Ring Buffer - 1024 samples
654
Processor
648

Fig. 58

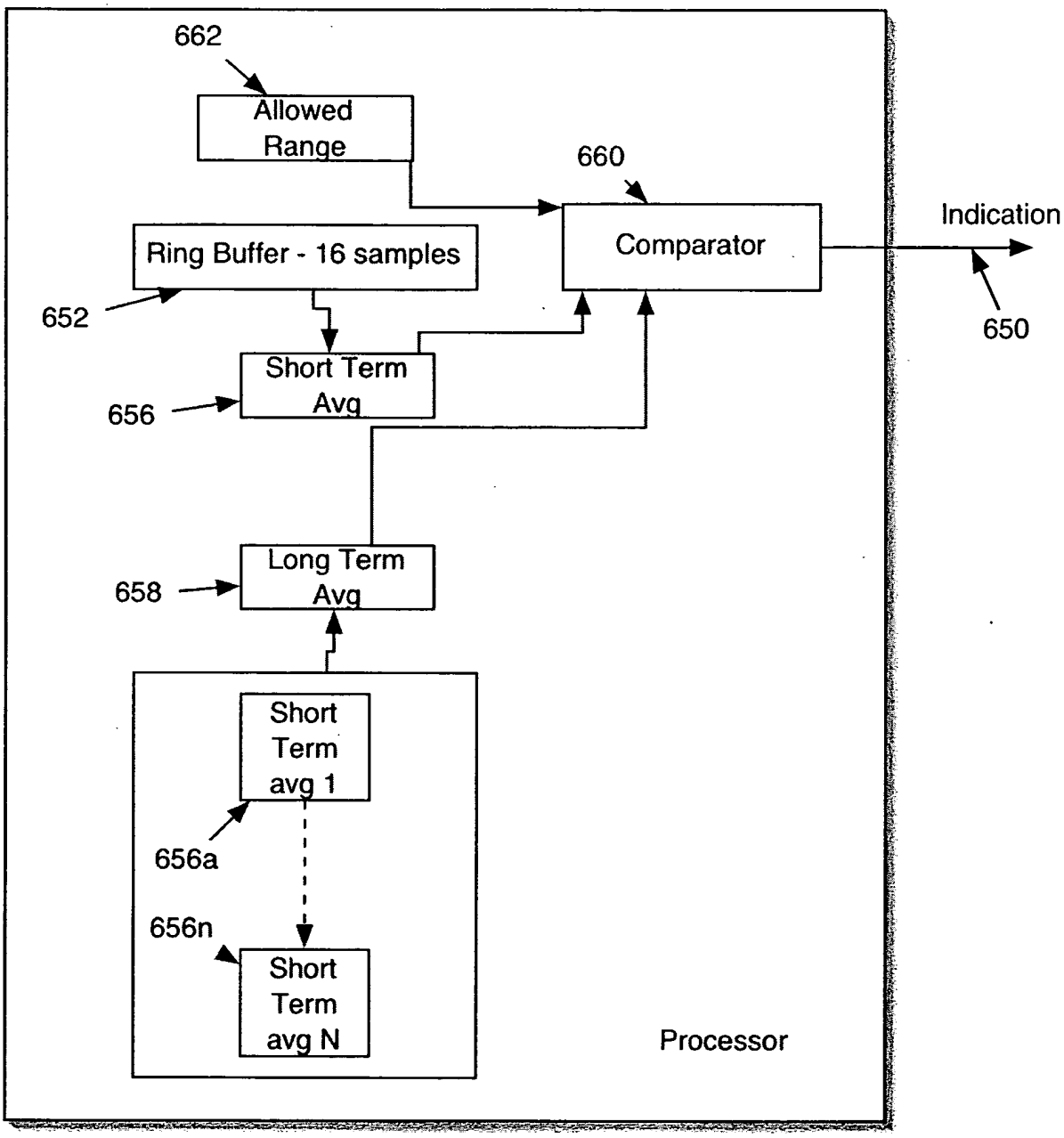

662
Allowed Range
660
Indication
Ring Buffer - 16 samples
Comparator
652
650
Short Term Avg
656
Long Term Avg
658
Short Term avg 1
656a
656n
Short Term avg N
Processor

Fig. 59